(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 457 294 A1

(12) EUROPEAN PATENT APPLICATION

published in accordance with Art. 158(3) EPC

(43) Date of publication:
15.09.2004 Bulletin 2004/38

(21) Application number: **02758875.5**

(22) Date of filing: **26.08.2002**

(51) Int Cl.[7]: **B25J 15/08**

(86) International application number:
PCT/JP2002/008570

(87) International publication number:
WO 2003/051583 (26.06.2003 Gazette 2003/26)

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR IE IT LI LU MC NL PT SE SK TR

(30) Priority: **17.12.2001 JP 2001382842**

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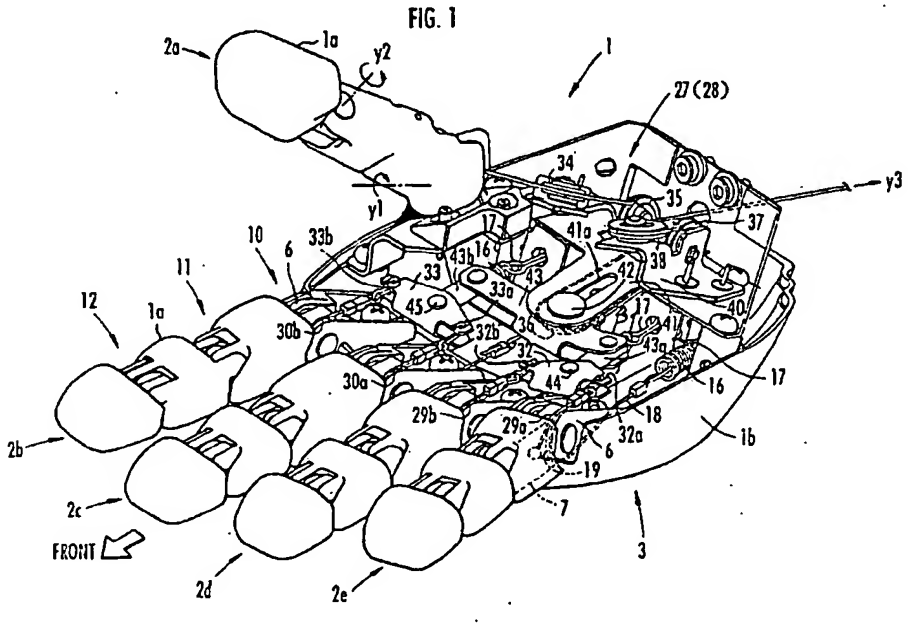
(54) MULTI-FINGER HAND DEVICE

(57) There is provided a multi-finger hand device which can perform smooth bending and stretching operations of finger mechanisms in holding work of an object or the like while reducing the number of actuators as driving sources of the bending and stretching operations of the finger mechanisms. Wires 29a and 29b, and wires 30a and 30b extending from the finger mechanisms 2a to 2e biased to the stretching side by springs 16, 26 or the like are joined to joining element 32 and 33, respectively. A wire 31 provided extensionally from the finger mechanism 2a is wound onto a pulley 36 and drawn from the base side of the hand 3. The joining elements 32 and 33 are rockably held by a holding element 43 via spindles 44 and 45. The holding element 43 is provided movably and rockably around a spindle 42. The pulley 36 is held by the holding element 43 and moves together with the holding element 43. By pulling the wire 31, the bending operations of the finger mechanisms 2a to 2e are performed collectively. During bending and stretching operations of the finger mechanisms 2a to 2e, even if any of the finger mechanisms touches an object or the like and is disabled to move, the bending and stretching operations of the other finger mechanisms can be performed.

FIG. 1



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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a multi-finger hand device having a plurality of finger mechanisms.

BACKGROUND ART

[0002] A multi-finger hand device having a structure similar to that of a human hand is configured such that a plurality of finger mechanisms are provided extensionally from a hand attached to a tip end of an arm, each having a plurality of interjoint elements sequentially connected via a plurality of finger joints.

[0003] In this type of multi-finger hand device, there have been known in the prior art those in which, for each finger mechanism, an actuator for driving the finger joints of the finger mechanism is provided apart from the finger mechanism (for example, in the hand or arm), this actuator is connected to the finger mechanism via a wire element and a pulley element onto which the wire element is wound, and the wire element is pulled by the actuator to allow the finger mechanism to perform bending and stretching operations (for example, refer to Japanese Patent Application Laid-Open No. 207795 (1985), Japanese Patent Application Laid-Open No. 8178 (1994) or the like).

[0004] However, these conventional multi-finger hand devices, being provided with an actuator for each finger mechanism, can control the bending and stretching operations of the respective finger mechanisms independently, while large space is necessary for mounting a number of actuators. Furthermore, since the wire element connecting the finger mechanism and the actuator corresponding to the same are required for each finger mechanism, space for arranging a number of wire elements is also necessary and the arrangement of the wire elements becomes complicated.

[0005] In order to solve such inconveniences, it can be considered that, for example, the respective finger mechanisms are biased via springs or the like toward their stretching side or bending side, that the wire elements provided extensionally from the respective finger mechanisms are combined with each other, and that the combined wire elements are pulled by a single actuator, whereby bending operations or stretching operations of the respective finger mechanisms can be performed collectively.

[0006] However, in such a case, for example, when the bending operations of the respective finger mechanisms are performed to hold an object, and one of the finger mechanisms touches the object or another obstacle, thereby being disabled to perform the bending operation further, the other finger mechanisms may also be disabled to perform their bending operations further, thereby being disabled to hold the object properly. Furthermore, in a case where the respective finger mechanisms are stretched from the bending state, when one of the finger mechanisms touches an obstacle or the like, thereby being disabled to perform the stretching operation further, the other finger mechanisms are also disabled to perform the stretching operations.

[0007] The present invention is achieved in view of the above-mentioned background, and it is an object of the present invention to provide a multi-finger hand device which bends and stretches a plurality of finger mechanisms via wire elements, wherein smooth bending and stretching operations of the finger mechanisms can be performed in holding work of an object or the like while reducing the number of actuators as driving sources of the bending and stretching operations of the finger mechanisms.

DISCLOSURE OF THE INVENTION

[0008] In order to achieve such an object, according to a first aspect of the present invention, there is provided a multi-finger hand device comprising: a hand attached to a tip end of an arm; a plurality of finger mechanisms provided extensionally from the hand each of which is structured to sequentially connect a plurality of interjoint elements via finger joints; biasing means for biasing the respective finger mechanisms to any one of the stretching direction and the bending direction; wire elements provided extensionally from the respective finger mechanisms to the hand side; and driving means for performing bending operations or stretching operations of the finger mechanisms by pulling the wire elements provided extensionally from the respective finger mechanisms against biasing forces of the biasing means, wherein: the driving means comprises a joining element having a pair of joining portions which join ends on the hand side of the two wire elements provided extensionally from at least two finger mechanisms of the plurality of finger mechanisms respectively with a space left therebetween, and a holding element which rockably holds the joining element via a supporting point provided between both the joining portions of the joining element and can move in a pulling direction of the two wire elements; and when the bending operations or the stretching operations of the two finger mechanisms are performed, the wire elements provided extensionally from the two finger mechanisms are pulled by moving the holding element.

[0009] The first aspect of the present embodiment has a structure suited for bending and stretching at least two finger mechanisms. Hereinafter, a description will be given supposing that two finger mechanisms are used. The finger mechanisms are provided, for example, with a plurality of joints and extend so as to bend and stretch freely by imitating a human hand. The wire elements extend from the respective finger mechanisms toward the hand, and by pulling the wire elements, the bending operations and the stretching operations of the respective finger mechanisms can be performed. The driving

means pulls both the wire elements provided extensionally from the two finger mechanisms concurrently via the joining element held by the holding element against the biasing forces of the biasing means, thereby performing the bending operations or the stretching operations of the two finger mechanisms (hereinafter referred to only as bending and stretching operations). Accordingly, with respect to the two finger mechanisms, the bending and stretching operations of both the finger mechanisms can be performed by only one actuator instead of providing one actuator for each of the finger mechanisms. Furthermore, at this time, even if any one of the two finger mechanisms touches an object or the like and the wire element thereof is disabled to be pulled, the joining element can rock like a scale via the supporting point and move together with the holding element while pulling the wire element of the other finger mechanism, whereby the bending and stretching operations of the other finger mechanism can be performed without any problem.

[0010] In this way, according to the first aspect of the present invention, the smooth bending and stretching operations of the finger mechanisms in holding work of an object or the like can be performed while reducing the number of the actuators as driving sources of the bending and stretching operations of the finger mechanisms. Incidentally, the first aspect of the present invention can also be employed in the case of two or more finger mechanisms, and with respect to the finger mechanisms other than the two finger mechanisms, the wire elements provided extensionally from the finger mechanisms may be pulled using individual actuators to perform the bending and stretching operations of the finger mechanisms. Alternatively, according to other structures of the present invention as described later, the bending and stretching operations can be performed using an actuator common to each other.

[0011] Furthermore, according to a second aspect of the present invention, there is provided a multi-finger hand device comprising: a hand attached to a tip end of an arm; at least four or more finger mechanisms provided extensionally from the hand each of which is structured to sequentially connect a plurality of interjoint elements via finger joints; biasing means for biasing the respective finger mechanisms to any one of the stretching direction and the bending direction; wire elements provided extensionally from the respective finger mechanisms to the hand side; and driving means for performing bending operations or stretching operations of the finger mechanisms by pulling the wire elements provided extensionally from the respective finger mechanisms against biasing forces of the biasing means, wherein: the driving means comprises two joining elements each having a pair of joining portions wherein at least four finger mechanisms of the plurality of finger mechanisms are classified into two pairs and the joining portions join ends on the hand side of the two wire elements provided extensionally from the two finger mechanisms of each of the two pairs with a space left therebetween, and a holding element which rockably holds the two joining elements with a space left therebetween via supporting points each provided between both the joining portions in each of the joining elements and can move in a pulling direction of the wire elements provided extensionally from the four finger mechanisms respectively and can rock around a supporting point provided between the two joining elements; and when the bending operations or the stretching operations of the four finger mechanisms are performed, the wire elements provided extensionally from the four finger mechanisms are pulled by moving the holding element.

[0012] The second aspect of the present invention has a structure suited for bending and stretching at least four finger mechanisms. Hereinafter, a description will be given supposing that four finger mechanisms are used. The driving means according to the second aspect of the present invention can pull the wire elements provided extensionally from the four finger mechanisms via the two joining elements against the biasing forces of the biasing means by moving the holding element. Thereby, the bending and stretching operations of the four finger mechanisms can be performed collectively, and the bending and stretching operations can be performed using a single actuator instead of providing actuators for the four finger mechanisms individually.

[0013] Here, the four finger mechanisms are classified into the two pairs and the respective wire elements are joined by the two joining elements. In other words, a pair of wire elements extended from the two finger mechanisms are joined by one of the joining elements, and a pair of wire elements extended from the remaining two finger mechanisms are joined by the other joining element. Then, even if any one of the four finger mechanisms touches an object or the like and is disabled to move, so that the wire element thereof becomes incapable of being pulled, the wire element provided extensionally from the finger mechanism paired with the finger mechanism which is disabled to move is pulled by the balance-like rocking of the joining element, and the bending and stretching operations of the finger mechanism paired with the finger mechanisms which is disabled to move can be performed without any problem. In addition, since the joining element corresponding to the two finger mechanisms of the pair other than the pair to which the finger mechanism disabled to move belongs is moved together with the holding element, the bending and stretching operations of the three finger mechanisms other than the finger mechanism disabled to move can be performed. This is also similar in a case where one finger mechanism belonging to one of the two pairs of the four finger mechanisms and one finger mechanism belonging to the other pair are disabled to move at the same time. In this case, both the joining elements can also move together with the holding element while rocking, whereby the bending and stretching operations of the two finger mechanisms other than the two finger mechanisms disabled to move can be per-

formed.

[0014] Furthermore, in a case where both of the two finger mechanisms belonging to one of the two pairs of the four finger mechanisms are disabled to move, the joining element corresponding to the finger mechanisms belonging to the pair is disabled to move together with the holding element, however, rocking of the holding element around the supporting point enables the joining element corresponding to the finger mechanisms of the other pair to move together with the holding element. Thereby, the bending and stretching operations of the finger mechanisms of the other pair can be performed. Similarly, even in a case where three finger mechanisms of the four finger mechanisms are disabled to move, since the joining element corresponding to one movable finger mechanism rocks and the holding element can move while rocking, the bending and stretching operations of the one movable finger mechanism can be performed.

[0015] In this way, according to the second aspect of the present invention, even if any finger mechanism of the four finger mechanisms touches an object or the like and is disabled to move, the remaining finger mechanisms can perform the bending and stretching operations. Then, the bending and stretching operations of the four finger mechanisms can be performed by moving the pulley holding element using a single actuator.

[0016] Hence, according to the second aspect of the present invention, similar to the above-mentioned first embodiment, the smooth bending and stretching operations of the finger mechanisms in holding work of an object or the like can be performed while reducing the number of the actuators as driving sources of the bending and stretching operations of the finger mechanisms. Incidentally, in the second aspect, the basic actuation of the two finger mechanisms of each of the pairs is similar to that of the first aspect.

[0017] Furthermore, the above-mentioned multi-finger hand device of the first aspect of the present invention comprises at least three or more said finger mechanisms, wherein: the driving means comprises a pulley element onto which the wire element provided extensionally from the one finger mechanism other than the two finger mechanisms is wound and which is held rotatably by the holding element; and when the bending operations or the stretching operations of the two finger mechanisms and the one other finger mechanism are performed, the wire element provided extensionally from the one other finger mechanism is pulled in such a direction that the pulley element moves in a pulling direction of the wire elements provided extensionally from the two finger mechanisms together with the holding element.

[0018] Thereby, by pulling the wire element provided extensionally from the one other finger mechanism, the bending and stretching operations of the one other finger mechanism are performed. In addition, by pulling the wire element provided extensionally from the one other finger mechanism, the holding element moves via the pulley element, and with this, the wire elements provided extensionally from the two finger mechanisms are pulled via the joining element. Thereby, only by pulling the wire element provided extensionally from the one other finger mechanism, the bending and stretching operations of not only the one other finger mechanism but the two finger mechanisms can be performed concurrently.

[0019] At this time, for example, even if the one other finger mechanism touches an object or the like and goes into an unmovable state, since the pulley element is provided in the movable holding element, the holding element is moved while the pulley element rotates, and the wire elements of the two finger mechanisms are pulled, so that with respect to the two finger mechanisms, the bending and stretching operations can be performed without any problem.

[0020] Furthermore, as for the two finger mechanisms, even if any one of them touches an object or the like and is disabled to move, the joining element rocks like a scale, so that the bending and stretching operations of the other finger mechanism is not inhibited, and further, since the wire element provided extensionally from the one other finger mechanism is pulled via the pulley element of the holding element, the bending and stretching operations of the one other finger mechanism are also performed without any problem.

[0021] Hence, according to the above-mentioned present invention, even if any finger mechanism of the three finger mechanisms consisting of the two finger mechanisms and the one other finger mechanism touches an object or the like and is disabled to move, the remaining finger mechanisms can perform the bending and stretching operations. In addition, the bending and stretching operations of the three finger mechanisms can be performed by the wire element provided extensionally from the one other finger mechanism using the single actuator.

[0022] Similar to the foregoing case, in the above-mentioned second aspect of the present invention, the multi-finger hand device comprises at least five or more said finger mechanisms, wherein: the driving means comprises a pulley element onto which the wire element provided extensionally from the one finger mechanism other than the four finger mechanisms is wound and which is held rotatably by the holding element between the two joining elements; and when the bending operations or the stretching operations of the four finger mechanisms and the one other finger mechanism are performed, the wire element provided extensionally from the one other finger mechanism is pulled in such a direction that the pulley element moves in a pulling direction of the wire elements provided extensionally from the four finger mechanisms together with the holding element.

[0023] Thereby, only by pulling the wire element provided extensionally from the one other finger mecha-

nism, the bending and stretching operations of the four finger mechanisms can be performed concurrently with the bending and stretching operations of the one other finger mechanism. In other words, by pulling the wire element provided extensionally from the one other finger mechanism, the holding element is moved via the pulley element, and the wire elements provided extensionally from the four finger mechanisms are pulled via the two joining elements provided in the holding element. At this time, for example, even if the one other finger mechanism touches an object or the like and goes into an unmovable state, since the pulley element is held by the movable holding element, the holding element is moved while the pulley element rotates, and the wire elements of the four finger mechanisms joined to the two joining elements are pulled, so that with respect to the four finger mechanisms, the bending and stretching operations can be performed without any problem. Furthermore, as for the four finger mechanisms, even if any of them touches an object or the like and is disabled to move, since the joining element corresponding to the remaining finger mechanisms other than the finger mechanism disabled to move can rock like a scale and move together with the holding element, the bending and stretching operations of the remaining finger mechanisms can be performed.

[0024] Hence, according to the above-mentioned present invention, even if any finger mechanism of the five finger mechanisms consisting of the four finger mechanisms and the one other finger mechanism touches an object or the like and is disabled to move, the remaining finger mechanisms can perform the bending and stretching operations. In addition, the bending and stretching operations of the five finger mechanisms can be performed by pulling the wire element provided extensionally from the one other finger mechanism using the single actuator.

[0025] Furthermore, in the second aspect of the present invention, even if the biasing forces of the respective biasing means are set to a constant value, by locating the supporting point of the holding element provided between the two joining elements closer to any one of the joining elements, the bending and stretching operation sequence of the two finger mechanisms belonging to one of the two pairs of the four finger mechanisms and the two finger mechanisms belonging to the other can be set easily. Specifically, for example, when the biasing means of the respective finger mechanisms have the same biasing force and the holding element is moved via the supporting point, firstly, the holding element rocks, and one of the joining elements at a shorter distance from the supporting point starts to move at an earlier timing than the other joining element at a longer distance from the supporting point. At this time, in a case where the respective biasing means bias the respective finger mechanisms to the stretching side, since the wire elements joined to the one joining element moved at an earlier timing are pulled earlier than the wire elements joined to the other joining element, the bending operations of the two finger elements belonging to the one can be started earlier than those of the two finger elements belonging to the other. Furthermore, in a case where the respective biasing means bias the respective finger mechanisms to the bending side, since the wire elements joined to the one joining element moved at an earlier timing are released earlier than the wire elements joined to the other joining element, the two finger mechanisms belonging to the one can start the stretching operations later than the two finger mechanisms belonging to the other. In this way, since the bending and stretching operation sequence of the finger mechanism can be set by the supporting point position of the holding element, cost increase can be prevented by using biasing means having the same biasing force without mounting biasing means having a different biasing force for each finger mechanism.

[0026] Furthermore, in the first and second aspects of the present invention, by locating the supporting point provided between the both joining portions of the joining element closer to any one of the joining portions, the bending and stretching operation sequence can be set easily with respect to the two finger mechanisms. This is basically similar to the above-mentioned case of the supporting point position of the holding element, and when the holding element is moved, the joining element rocks around the supporting point and the wire element joined to one joining portion at a shorter distance from the supporting point is pulled at an earlier timing than the wire element joined to the other joining portion at a longer distance from the supporting point.

[0027] In addition, for example, in the multi-finger hand device of the present invention, when the four finger mechanisms correspond to an index finger to a little finger by imitating a human hand, by combining the supporting point position of the joining element and the supporting point position of the holding element, the bending operations from the little finger to the index finger can be continued with a slight sequential delay, so that a natural gripping operation imitating a human hand can be achieved easily.

[0028] Furthermore, in the present invention, it is preferable that the joining element is held by the holding element via a link element provided consecutively and rockably to the holding element. Thereby, even when the holding element is provided closer to the arm in the hand, the joining element can be made closer to the respective finger mechanisms by the link element, whereby the length of the respective wire elements is saved to reduce cost. In addition, the rockable link element can absorb a circular arc activation when the holding element rocks around the supporting point thereof to transmit it as a substantially linear operation to the joining element, and the stable bending and stretching operations of the finger mechanisms can be performed.

[0029] Furthermore, in the present invention, the wire elements provided extensionally from the respective fin-

ger mechanisms, for example, may be provided extensionally from the tip ends of the respective finger mechanisms, however, as a more preferable structure, it is cited that at least one finger mechanism of the plurality of the finger mechanisms comprises a link mechanism joined to the plurality of interjoint elements of the finger mechanism, so that rotational operations around the other finger joints are performed in conjunction with a rotational operation of the interjoint element continued into the finger joint closest to the hand around the finger joint, and the wire element provided extensionally from the finger mechanism is provided extensionally from the interjoint element closest to the hand.

[0030] According to this, with respect to the respective finger mechanisms comprising the link mechanism, by pulling the wire element provided extensionally from the interjoint element closest to the hand and rotating the interjoint element closest to the hand around the finger joint closest to the hand, the bending and stretching of the other joints are performed in conjunction with this, and the bending and stretching operations of the finger mechanism are performed. The wire element, therefore, needs only to be extended from the hand to the interjoint element closest to the same, which allows the length thereof to be shorter. Thereby, the length of the wire element can be saved to reduce cost.

[0031] Furthermore, it is preferable that the two or more interjoint elements of each of the two or more finger mechanisms among the plurality of finger mechanisms have an identical structure.

[0032] According to this, since the two or more finger mechanisms can use the same interjoint element, required components of the multi-finger hand device can be reduced in type, which makes the component management, maintenance or the like easier.

[0033] Furthermore, in the present invention, in a case where the hand is provided rotatably around a shaft center extending in a substantially longitudinal direction of the arm, it is preferable that the driving means comprises at least one driving wire element provided extensionally from the hand to the inside of the arm, and an actuator for applying to the driving wire element a driving force for pulling the driving wire element toward the inside of the arm, the driving means transmitting the force of pulling the wire elements provided extensionally from the respective finger mechanisms from the actuator to the hand side via the driving wire element, and the driving wire element is arranged into the arm along the rotation shaft center of the hand.

[0034] According to this, since the driving wire element is arranged into the arm along the rotation shaft center of the hand, even if the hand is rotated with respect to the arm, the driving wire element is not pulled. Accordingly, the hand can be rotated with respect to the arm while maintaining bending and stretching states of the finger mechanisms provided extensionally from the hand. Furthermore, by arranging the actuator inside of the arm, the structure of the hand can be downsized.

[0035] Incidentally, in the case where the multi-finger hand device comprises, for example, five finger mechanisms, as in the above-mentioned invention of the second aspect, when the pair of joining elements and the pulley element are provided, the driving wire element is integral with the wire element provided extensionally from the one other finger mechanism or made of only one wire element obtained by connecting with the wire element.

[0036] Then, in this way, in the multi-finger hand device of the present invention in which the hand rotates with respect to the arm, it is preferable that the arm and the hand are insulated electrically and the driving wire element is formed of an insulating material.

[0037] According to this, even if the hand and the finger mechanisms are immersed in water, electric leakage from an electrical component system inside of the arm or the like to the hand side, or the like never occurs. Therefore, work such as holding an object in water can be performed by the multi-finger hand device without any problem.

[0038] Incidentally, in the present invention as described above, in the case where the finger mechanisms are biased to the stretching side by the biasing means, a force when holding an object by the multi-finger hand device can be adjusted by controlling the pulling force of the wire elements provided extensionally from the respective finger mechanisms, and in the case where the respective finger mechanisms are biased to the bending side by the biasing means, the force when holding an object can be adjusted by adjusting the biasing force of the biasing means.

[0039] Furthermore, in the present invention as described above, the "wire element" includes elements such as chains and belts as well as wires in a typical sense, and the "pulley element" includes gears, sprockets or the like as well as pulleys in a typical sense.

BRIEF DESCRIPTION OF DRAWINGS

[0040]

FIG. 1 is a perspective view of a multi-finger hand device according to one embodiment of the present invention.

FIG. 2 is a plan view showing a substantial part structure of the multi-finger hand device of FIG. 1.

FIG. 3 is a cross-sectional view taken along the line III-III of FIG. 2.

FIG. 4 is a cross-sectional view showing an internal structure of an arm with the multi-finger hand device of FIG. 1 attached.

FIG. 5 is a cross-sectional view taken along the line IV-IV of FIG. 4.

FIGS. 6(a) and 6(b) are views for explaining an actuation of the substantial part of the multi-finger hand device of FIG. 1.

BEST MODE OF CARRYING OUT THE INVENTION

[0041] One embodiment of a multi-finger hand device of the present invention will be described in reference to FIGS. 1 to 6. Incidentally, the present embodiment corresponds to both of the first aspect and the second aspect according to the present invention.

[0042] As shown in FIG. 1, a multi-finger hand device 1 according to the present embodiment is formed by imitating a human hand, comprising five finger mechanisms 2a to 2e corresponding to five fingers and a hand 3 corresponding to a palm. The finger mechanisms 2a to 2e correspond to a thumb, index finger, middle finger, ring finger, and little finger in a human hand, respectively. The hand 3 is joined rotatably via a wrist base 4 to an arm 5, a part of which is shown in FIG. 4. The arm 5 is provided in a robot body of a humanoid or the like, which is not shown in the figure.

[0043] Here, as shown in FIG. 1, each of the finger mechanisms 2a to 2e is covered with a finger cover element 1a in such a manner as to bend and stretch. The hand 3 is covered with an element for back of hand formation 1b on the side of a back of hand and with an element for palm formation not shown in the figure on the side of a palm. In the drawings of the present embodiment including FIG. 1, the drawing of the element for palm formation is omitted in order to illustrate an internal structure of the hand 3. In FIG. 1, the element for back of hand formation 1b is located in the lower part of the hand 3, while the element for palm formation is assembled on the upper side of this element for back of hand formation 1b.

[0044] Among the finger mechanisms 2a to 2e, the four finger mechanisms 2b to 2e except for the finger mechanism 2a corresponding to the thumb are identical in fundamental structure. Firstly, the structure related to these four finger mechanisms 2b to 2e will be described below. As shown in FIG. 2, each of these four finger mechanisms 2b to 2e has a structure that a fixing element 6 which is provided fixedly to an end of the element for back of hand formation 1b of the hand 3 (an end on the opposite side of the arm 5) and three interjoint elements, that is, first to third elements 7, 8 and 9 are connected via three joints, that is, first to third joints 10 to 12 in order. Incidentally, since the fundamental structures of the finger mechanisms 2b to 2e are identical to each other as described above, in respective drawings of the present embodiment, for only some finger mechanisms of the finger mechanisms 2b to 2e, reference numerals and signs of their components (interjoint elements, joints and the like) will be representatively described, and those of other finger mechanisms will be omitted.

[0045] The joints 10 to 12 of the respective finger mechanisms 2b to 2e are joints each of which performs a relatively rotational operation around a uniaxis between the elements which the joint joins, and has joint shafts 10a to 12a. These joint shafts 10a to 12a extend in parallel with each other in a substantially width direction of the hand 3 (a direction in which the finger mechanisms 2b to 2e are substantially in parallel). Then, the first joint 10 joins the fixing element 6 and the first interjoint element 7 via the joint shaft 10a in such a manner that the element 7 can rotate around a shaft center of the joint shaft 10a with respect to the fixing element 6, the second joint 11 joins the first interjoint element 7 and the second interjoint element 8 via the joint shaft 11a in such a manner that the element 8 can rotate around a shaft center of the joint shaft 11a with respect to the element 7, and the third joint 12 joins the second interjoint element 8 and the third interjoint element 9 via the joint shaft 12a in such a manner that the element 9 can rotate around a shaft center of the joint shaft 12a with respect to the element 8. These relative rotational operations of the interjoint elements 7 to 9 in the respective joints 10 to 12 enable the bending and stretching operations of the respective finger mechanisms 2b to 2e.

[0046] Furthermore, each of the finger mechanisms 2b to 2e is provided with a link mechanism 13 which conjunctionally rotates the second interjoint element 8 and the third interjoint element 9 when the first interjoint element 7, which is closest to the hand 3, is rotated with respect to the fixing element 6.

[0047] The structures of these link mechanisms 13 are identical to each other with respect to any of finger mechanisms 2b to 2e, and for these structures, for example, the finger mechanism 2c will be described in reference to FIG. 3. The link mechanism 13 comprises a link arm 14 which joins the fixing element 6 and the second interjoint element 8, and a link arm 15 which joins the first interjoint element 7 and the third interjoint element 9. One end of the link arm 14 is supported rotatably by the fitting element 6 via a spindle 14a at a position closer to a face portion on the back side of the finger mechanism 2c (lower portion in FIG. 3) than the joint shaft 10a of the first joint 10, and the other end thereof is supported rotatably by the second interjoint element 8 via a spindle 14b at a position closer to a face portion on the belly side of the finger mechanism 2c (upper portion in FIG. 3) than the joint shaft 11a of the second joint 11.

[0048] Furthermore, one end of the link arm 15 is supported rotatably by the first interjoint element 7 via a spindle 15a at a position closer to a face portion on the back side of the finger mechanism 2c than the joint shaft 11a of the second joint 11, and the other end thereof is supported rotatably by the third interjoint element 9 via a spindle 15b at a position closer to a face portion on the belly side of the finger mechanism 2c than the joint shaft 12a of the third joint 12.

[0049] In the finger mechanism 2c comprising the link mechanism 13 having such a structure, when the first interjoint element 7 is rotated in a clockwise direction (direction in which the face portion on the belly side of the first interjoint element 7 approaches a face portion on the palm side of the hand 3) with respect to the fixing

element 6 from a state in which the finger mechanisms 2c is stretched as shown in solid lines in FIG. 3, the second interjoint element 8 conjunctionally rotates in a clockwise direction with respect to the first interjoint element 7 as shown in virtual lines of the same figure, and the third interjoint element 9 rotates in a clockwise direction with respect to the second interjoint element 8. Thereby, the finger mechanism 2c bends at the respective joints 10 to 12. Furthermore, on the contrary to the foregoing, when the first interjoint element 7 is rotated in a counterclockwise direction with respect to the fixing element 6 from the state in which the finger mechanism 2c is bent as shown in the virtual lines of the same figure to return to the position shown in the solid lines of the same figure, the second interjoint element 8 and the third interjoint element 9 conjunctionally rotate in counterclockwise directions with respect to the first interjoint element 7 and the second interjoint element 8, respectively to stretch the finger mechanism 2c. In this manner, the bending and stretching of the finger mechanism 2c is performed by rotating the first interjoint element 7 with respect to the fixing element 6. Such a structure of the link mechanism 13 and the bending and stretching operations of the finger mechanism entailed by the same are completely similar with respect to the finger mechanisms 2b, 2d and 2e.

[0050] Incidentally, according to the present embodiment, parts of the finger mechanisms 2b to 2e from the second joint 11 to the finger tip side (parts each made of the second interjoint element 8, the third interjoint element 9, the third joint 12, and the link arm 15) are identical to each other not only in fundamental structure but also in shape and size of each component.

[0051] In reference to FIGS. 1 and 2, a spring 16 as biasing means for biasing each of the finger mechanisms 2b to 2e of the above-mentioned structure to the stretching side is arranged inside of the hand 3 for each of the finger mechanisms 2b to 2e. Incidentally, in FIG. 1, a part of the spring 16 of the finger mechanism 2b and the spring 16 of the finger mechanism 2e are shown, and in FIG. 2, the spring 16 of the finger mechanisms 2c to 2e are partially shown.

[0052] One end of the spring 16 is latched onto a spring locking part provided in the element for back of hand formation 1b, which is not shown in the figure, via a latch element 17 (partially shown in FIG. 1), and as shown in FIG. 2, the other end thereof is locked onto the corresponding first interjoint element 7 of the finger mechanisms 2b to 2e via a wire element for biasing 18. In this case, a guide pulley 19 which is rotatable around the joint shaft 10a is arranged concentrically with the joint shaft 10 at a position closer to a side face of the first joint 10 of each of the finger mechanisms 2b to 2e, and the wire element for biasing 18 is fixed to a side face portion of the first interjoint element 7 via an outer periphery on the lower side of this guide pulley 19 (the back side of each of the finger mechanisms 2b to 2e). Incidentally, the fixing portion of the wire element for biasing 18 with respect to the first interjoint element 7 is located on upper side than a lower end of the guide pulley 19 in a vertical direction.

[0053] This structure allows each of the mechanisms 2b to 2e to be biased in the state in which each of the finger mechanisms 2b to 2e are stretched by a biasing force of the corresponding spring 16.

[0054] Incidentally, in the description below, for convenience of the description, the extending direction of the finger mechanisms 2b to 2e in the stretching state is referred to as a broadly anteroposterior direction of the multi-finger hand device 1, and the tip end side of the finger mechanisms 2b to 2e is referred to as the front side of the multi-finger hand device 1.

[0055] In reference to FIG. 2, the finger mechanism 2a equivalent to the thumb has a structure that a fixing element 20 which is provided fixedly to the element for back of hand formation 1b of the hand 3 at the rear of the fixing element 6 of the finger mechanism 2b and two interjoint elements, that is, first and second elements 21 and 22 are connected consecutively via two joints, that is, first and second joints 23 and 24 in order. Incidentally, in FIG. 2, in order to show an internal structure of the finger mechanism 2a, for the first interjoint element 21 and the second interjoint element 22, only the outlines thereof are shown.

[0056] The respective joints 23 and 24 of the finger mechanism 2a are joints each of which performs a relative rotational operation around a uniaxis between the elements which the joint joins, and has joint shafts 23a to 24a. Then, the joint shaft 23a of the first joints 23 are oriented in a slightly inclined direction with respect to the anteroposterior direction of the multi-finger hand device 1, and the joint shaft 24a of the second joint 24 is oriented in a direction substantially straight to the joint 23a of the first joint 23. Then, the first joint 23 joins the fixing element 20 and the first interjoint element 21 via the joint shaft 23a in such a manner that the element 21 can rotate around a shaft center of the joint shaft 23a with respect to the fixing element 20, and the second joint 24 joins the first interjoint element 21 and the second interjoint element 22 via the joint shaft 24a in such a manner that the element 22 can rotate around a shaft center of the joint shaft 24a with respect to the element 21. These relative rotational operations of the interjoint elements 21 and 22 in the respective joints 23 and 24 enable the bending and stretching operations of the finger mechanism 2a.

[0057] In this case, as shown in FIGS. 1 to 2, a bending operation from the state that the finger mechanism 2a is stretched is performed as follows. Specifically, when the finger mechanism 2a is bent from the state that the finger mechanism 2a is stretched, the first interjoint element 21 is rotated around the shaft center of the joint shaft 23a of the first joint 23 with respect to the fixing element 20 (the first interjoint element 21 is rotated in a direction of an arrow y1 in FIG. 2) so that the first interjoint element 21 approaches the hand 3 side, and the

second interjoint element 22 is rotated around the shaft center of the joint shaft 24a of the second joint 24 with respect to the first interjoint element 21 (the second interjoint element 22 is rotated in a direction of an arrow y2 in FIG. 2) so that a tip end of the second interjoint element 22 approaches the other finger mechanisms 2b to 2e.

[0058] As biasing means for biasing this finger mechanism 2a to the stretching side, a spring 26 shown in FIG. 2 and another spring not shown in the figure are provided. One end of the other spring not shown in the figure is locked onto the element for back of hand formation 1b of the hand 3, and the other end thereof is locked onto the first interjoint element 21 on the side closer to a rim of the hand 3 than the joint shaft 23a of the first joint 23. Thereby, the first interjoint element 21 is biased to the stretching side of the finger mechanism 2a (the opposite direction side of the arrow y1 in FIG. 2) by a biasing force of the other spring. Furthermore, one end of the spring 26 shown in FIG. 2 is locked onto the first interjoint element 21, and the other end thereof is locked onto the second interjoint element 22 on the back side of the finger mechanism 2a as compared to the joint shaft 24a of the second joint 24 (almost on right side of the joint shaft 24a in FIG. 2). Thereby, the second interjoint element 22 is biased to the stretching side of the finger mechanism 2a (the opposite direction side of the arrow y2 in FIG. 2) by a biasing force of the spring 26.

[0059] As shown in FIGS. 1 and 2, a driving mechanism 27 for performing the bending and stretching operations of the finger mechanisms 2a to 2e configured as the foregoing is included in the hand 3. This driving mechanism 27 makes up driving means 28 of the present invention together with a motor 56 (actuator) described later.

[0060] This driving mechanism 27 comprises five wires 29a, 29b, 30a, 30b and 31 (wire elements), two joining elements 32 and 33, and five pulleys 34 to 38.

[0061] As shown in FIG. 1, one end of the wire 29a is fixed to the side face portion on the guide pulley 19 side in the first interjoint element 7 of the finger mechanism 2e, and the other end thereof is joined to a first joining portion 32a of the one joining element 32. Although not shown in the figure, similarly, one end of the wire 29b is fixed to a side face portion on the guide pulley 19 side in the first interjoint element 7 of the finger mechanism 2d, and the other end thereof is joined to a second joining portion 32b of the one joining element 32. Similarly, one end of the wire 30a is fixed to a side face portion on the guide pulley 19 side in the first interjoint element 7 of the finger mechanism 2c, and the other end thereof is joined to a first joining portion 33a of the other joining element 33, and one end of the wire 30b is fixed to a side face portion on the guide pulley 19 side in the first interjoint element 7 of the finger mechanism 2b, and the other end thereof is joined to a second joining portion 33b of the other joining element 33.

[0062] As shown in FIGS. 1, 2 and 6, the joining elements 32 and 33 are held inside of the hand 3 as follows. Specifically, a bracket 40 extending in the width direction of the hand 3 whose tip end bends is provided fixedly at a position closer to a wrist in the element for back of hand formation 1b of the hand 3, and from the bracket 40, an auxiliary element 41 is provided extensionally toward interspace between the finger mechanisms 2c and 2d. On the center line of this auxiliary element 41, a kerf 41a extending in the anteroposterior direction is formed, and a spindle 42 having a shaft center in the vertical direction is engaged in this kerf 41a. The spindle 42 is rendered movable along the kerf 41a in the anteroposterior direction. Furthermore, a holding element 43 extending in the width direction of the hand 3 is attached to the spindle 42. The holding element 43 is rendered rockable around the spindle 42, and movable along the kerf 41a in the anteroposterior direction together with the spindle 42. Then, link elements 43a and 43b are joined from both ends of the holding element 43, and the joining elements 32 and 33 are rockably joined to tip ends of the respective link elements 43a and 43b via spindles 44 and 45.

[0063] Furthermore, in the joining element 32, the distance from the spindle 44 to the first joining portion 32a is rendered smaller than that from the spindle 44 to the second joining portion 32b, so that with the spindle 44 serving as a supporting point, the supporting point is closer to the first joining portion 32a. In the joining element 33, the distance from the spindle 45 to the first joining portion 33a is rendered smaller than that from the spindle 45 to the second joining portion 33b, so that with the spindle 45 serving as a supporting point, the supporting point is closer to the first joining portion 33a. Furthermore, in the holding element 43, the distance from the spindle 42 thereof to the spindle 44 of the joining element 32 on the side of the finger mechanisms 2d and 2e is rendered smaller than the distance from the spindle 42 to the spindle 45 of the joining element 33 on the side of the finger mechanisms 2b and 2c.

[0064] This structure enables the joining elements 32 and 33 to move together with the holding element 43 in the anteroposterior direction, and to rock around the spindle 42 between these joining elements 32 and 33.

[0065] One end of the wire 31, as shown in FIG. 2, is fixed to a tip end of the second interjoint element 22 of the finger mechanism 2a inside of the finger mechanism 2a, and from the tip end, the wire 31 goes through an outer periphery of the joint shaft 24a of the second joint 24 on the belly side of the finger mechanism 2a (an outer periphery of the joint shaft 24a on the left side in FIG. 2), and an outer periphery of a guide pulley 46a attached to the joint shaft 23a so as to freely rotate around the joint shaft 23a of the first joint 23 inside of the finger mechanism 2a, and is drawn from the fixing element 20 into the hand 3. In this case, inside of the first interjoint element 21, two guide pulley 46b and 46c for guiding the wire 31 from the tip end of the second interjoint element 22 to the guide pulley 46a while orienting the wire

31 to a required direction are supported rotatably, and the part of the wire 31 between the joint shaft 24a and the guide pulley 46a is also wound around the guide pulleys 46b and 46c. The guide pulley 46b is provided at such a position that a force in a bending direction of the finger mechanism 2a acts on the first interjoint element 21 around the shaft center of the joint shaft 23a of the first joint 23 when the part of the wire 31 which is drawn from the fixing element 20 is pulled. Similarly, the guide pulley 46c is provided at such a position that the force in the bending direction of the finger mechanism 2a acts on the second interjoint element 22 around the shaft center of the joint shaft 24a of the second joint 24 when the part of the wire 31 which is drawn from the fixing element 20 is pulled.

[0066] Furthermore, the wire 31 drawn from the fixing element 20 of the finger mechanism 2a sequentially goes through outer peripheries of the pulleys 34 and 35, which are rotatably supported by the bracket 40 in required postures at positions at the rear of the pulley 36 and closer to the fixing element 20, and thereafter, is wound around an outer periphery on the front side in the pulley 36, which is rotatably supported concentrically with the spindle 42 by the holding element 43. The pulley 36 is equivalent to the pulley element according to the present invention.

[0067] Furthermore, the wire 31, after being drawn rearward from the pulley 36, goes through outer peripheries of the pulleys 37 and 38, which are rotatably supported by the bracket 40 in required postures at the rear of the pulley 36, and penetrates the inside of the wrist base 4 to be introduced to the inside of the arm 5, as shown in FIG. 4.

[0068] Incidentally, the pulleys 34, 35, 37 and 38 are intended to regulate the orientation and wiring position of the wire 31, and mere rod-like elements may be fixed to the bracket 40 instead of these pulleys 34, 35, 37 and 38 as long as the elements have a relatively small friction with the wire 31, and the wire 31 may be wound around outer peripherics of these rod-like elements. This is similar with respect to the guide pulleys 46a to 46c provided in the finger mechanism 2a, and further similar with respect to the guide pulleys 19 of the finger mechanisms 2b to 2e around which the wires 29a, 29b, 30a and 30b and the wires 18 relating to the biasing means are wound.

[0069] Next, the substantial part structure of the arm 5 to which the wire 31 drawn from the side of the hand 3 is introduced will be described in reference to FIGS. 4 and 5.

[0070] As shown in FIG. 4, the arm 5 is provided with a machine frame 51 on which an actuator or the like is mounted at a tip end inside of an arm housing 50 which forms an outer peripheral face portion thereof. Then, a joining shaft 52 which joins the wrist base 4 of the hand 3 is rotatably supported by this machine frame 51 via a pair of bearings 53 and 54 with a shaft center thereof oriented toward a longitudinal direction of the arm 5, and on the rear side of the joining shaft 52, a driving motor 55 for rotating the hand 3 with respect to the arm 5 (hereinafter referred to as a motor for hand rotation 55) and the driving motor 56 for pulling the wire 31 (hereinafter referred to as the motor for finger driving 56) are mounted.

[0071] A front end of the joining shaft 52 is projected from the inside of the arm housing 50, and the wrist base 4 of the hand 3 is joined to the projected portion via a screw 57 concentrically with the joining shaft 52. This enables the hand 3 to rotate around a shaft center of the joining shaft 52 integrally with the joining shaft 52. Furthermore, a through-hole 52a is drilled in a shaft center portion of the joining shaft 52, and the wire 31 drawn from the hand 3 side is derived to the rear of the joining shaft 52 through the through-hole 52a.

[0072] Furthermore, at the rear of the joining shaft 52, there is provided a winding-up shaft 58 extending in a direction straight to the shaft center of the joining shaft 52, and this winding-up shaft 58 is rotatably supported by the machine frame 51 at the both ends. Then, the wire 31 derived from the through-hole 52a of the joining shaft 52 is locked onto this winding-up shaft 58, and by rotating the winding-up shaft 58 in a predetermined direction, the wire 31 is wound around the winding-up shaft 58 to be pulled.

[0073] The motor for finger driving 56 is mounted on the machine frame 51 side by side and in parallel with the winding-up shaft 58, and a driving gear 59 attached to a rotation driving shaft 56a of the motor for finger driving 56 is connected to a driven pulley 60 attached to the winding-up shaft 58 via a belt element 61. Accordingly, the winding-up shaft 58 is rotationally driven, and the wire 31 is wound around the winding-up shaft 58 or the winding is released by normal rotation actuation and reverse rotation actuation of this motor for finger driving 56.

[0074] Incidentally, the part of the wire 31 inside of the arm 5 is equivalent to the driving wire according to the present invention.

[0075] Furthermore, a driven pulley 62 is attached by insertion to an outer peripheral portion of the joining shaft 52 so as to freely rotate integrally with the joining shaft 52. Then, the motor for hand rotation 55 is mounted on the machine frame 51 in a posture parallel to the joining shaft 52, and as shown in FIG. 5, a gear 63 attached to a rotation driving shaft 55a of the motor for hand rotation 55 is connected to the driven pulley 62 of the joining shaft 52 via a belt element 64. Accordingly, the joining shaft 52 is rotationally driven by normal rotation actuation and reverse rotation actuation of the motor for hand rotation 55, and herewith, the hand 3 rotates around the shaft center of the joining shaft 52 together with the wrist base 4 joined to the joining shaft 52.

[0076] Incidentally, according to the present embodiment, the joining shaft 52 and the wire 31 are made of an insulating material such as a resin material. Furthermore, the arm housing 50, including a part 50a in which

it contacts the wrist base 4 (refer to FIG. 4), is made of a resin material. Accordingly, the arm 5 and the hand 3 are insulated electrically.

[0077] Furthermore, inside of the housing 50, there is provided an encoder for detecting a rotational position of the motor for hand rotation 55 (this is equivalent to a rotational position of the hand 3 with respect to the arm 5) and a rotational position of the motor for finger driving 56 (this is equivalent to a winding-up amount of the wire 31 onto the winding-up shaft 58), the drawing of which is omitted. Then, control over the actuation of the motor for hand rotation 55 and the motor for finger driving 56 is performed by a controller not shown in the figure on the basis of detection data of the encoder or the like.

[0078] Next, the actuation of the multi-finger hand device 1 according to the present embodiment will be described. Firstly, the fundamental actuation of the multi-finger hand device 1 will be described. Among the finger mechanisms 2a to 2e, the finger mechanisms 2b to 2e stay stretched by the biasing forces of the springs 16 corresponding to the respective finger mechanisms as shown in FIGS. 1 and 2 at normal time. Similarly, the finger mechanism 2a, as shown in FIGS. 1 and 2, stays stretched by the biasing force of the spring 26 and the other spring not shown in the figure at normal time.

[0079] In this state, when the motor for finger driving 56 inside of the arm 5 is actuated to rotationally drive the winding-up shaft 58 toward a winding-up direction of the wire 31 extending from the hand 3 into the arm 5, the wire 31 is pulled in a direction indicated by an arrow y3 in FIGS. 1 and 2. At this time, the tip end of the second interjoint element 22 of the finger mechanism 2a is pulled toward the bending side of the finger mechanism 2a via the wire 31, and the pulley 36 is pulled rearward. Then, basically, the holding element 43 and the joining elements 32 and 33, together with this pulley 36, move rearward from a state shown in FIG. 6(a) to that shown in FIG. 6(b), and consequently, the first interjoint elements 7 and 7 of the finger mechanisms 2d and 2e are pulled toward the bending side of the finger mechanisms 2d and 2e via the wires 29a and 29b, and the first interjoint elements 7 and 7 of the finger mechanisms 2b and 2c are pulled toward the bending side of the finger mechanisms 2b and 2c via the wires 30a and 30b. Thereby, all of the finger mechanisms 2a to 2e are bent so as to hold an object, which is not shown in the figure, therebetween. In other words, the wire 31 is pulled from the hand 3 side to the arm 5 side by the driving force of the single motor for finger driving 56 to be wound up around the winding-up shaft 58, thereby performing the bending operations of the five finger mechanisms 2a to 2e collectively. Thereby, work such as holding an object can be performed using the finger mechanisms 2a to 2e.

[0080] On the other hand, in the multi-finger hand device 1 according to the present embodiment, in the bending operations of the finger mechanisms 2a to 2e as described above, when the holding element 43 and the joining elements 32 and 33 move rearward, the holding member 43 is inclined to move the joining element 32 on the side of the finger mechanisms 2d and 2e slightly earlier, since the distance from the spindle 42 of the holding element 43 to the spindle 44 of the joining element 32 on the side of the finger mechanisms 2d and 2e is rendered smaller than the distance from the spindle 42 to the spindle 45 of the joining element 33 on the side of the finger mechanisms 2b and 2c, as is shown in FIG. 6(b). Furthermore, in the joining elements 32 and 33, since the distances from the respective spindles 44 and 45 to the first joining portions 32a and 33a are rendered smaller than the distances from the respective spindles 44 and 45 to the second joining portions 32b and 33b, the respective joining elements 32 and 33 are inclined, so that the wire 29a is pulled with an earlier timing than the wire 29b and the wire 30a is pulled with an earlier timing than the wire 30b. Thereby, the finger mechanisms 2e, 2d, 2c and 2b can be continuously bent with a slight delay in this sequence to thereby imitate a gripping operation in a natural form like that of a human hand. Incidentally, although such a bending operation sequence of the finger mechanisms 2a to 2e can be realized by setting the biasing forces of the springs 16 so as to be decreased in the order of 2e, 2d, 2c and 2b, the springs 16 of plural types having different biasing forces need to be used, which not only makes the handling troublesome but causes a possibility of improper mounting. In contrast, according to the present embodiment, the bending and stretching operation sequence of the finger mechanisms can be set mechanically by the supporting point position corresponding to the spindle 42 of the holding element 43 and the supporting point positions corresponding to the spindles 44 and 45 of the respective joining elements 32 and 33, so that the bending and stretching operation sequence of the finger mechanisms imitating a human hand can be achieved more easily than the case using the springs 16 having plural types of biasing forces.

[0081] In addition, according to the multi-finger hand device 1 of the present embodiment, even if any one of the finger mechanisms touches an object to be held and is disabled to bend further, the bending operations of the other finger mechanisms can be performed. Specifically, during the bending operations of the finger mechanisms 2a to 2e, for example, even if the finger mechanism 2e touches an object not shown in the figure and is disabled to bend further, as long as the finger mechanism 2d next to this finger mechanism 2e can bend further, the joining element 32, to which the wire 29a joined to this finger mechanism 2e is joined, can absorb an amount in which the wire 29a cannot be pulled, by balance-like inclination via the spindle 44, and can move toward the rear side while pulling the wire 29b of the finger mechanism 2d.

[0082] Furthermore, similarly, the joining element 33, to which the wires 30a and 30b provided extensionally from the finger mechanisms 2b and 2c are joined, can move toward the rear side while inclining via the spindle

45 as long as at least any one of the finger mechanisms 2b and 2c can bend further. Furthermore, as for the finger mechanism 2a, as long as it can bend further, by winding up the wire 31 around the winding-up shaft 58 inside of the arm 5, the length of a part from the pulley 34 of the wire 31 to the tip end of the finger mechanism 2a is decreased, so that the bending operation of the finger mechanism 2a is performed.

[0083] Still furthermore, when the finger mechanism 2a cannot bend any more, the length of the part of the wire 31 from the pulley 34 to the tip end of the finger mechanism 2a does not vary, however, by winding up the wire 31 around the winding-up shaft 58 inside of the arm 5, the pulley 36 moves toward the rear side together with the joining elements 32 and 33 on both sides thereof via the holding element 43. Therefore, the bending operations of the finger mechanisms 2b to 2e can be performed without any problem.

[0084] In this way, even when any one of the finger mechanisms is disabled to bend, since the joining elements 32 and 33 can be moved toward the arm 5 side together with the pulley holding element 43 and the pulley 36 while winding up the wire 31 around the winding-up shaft 58, the bending operations of the other finger mechanisms which can bend can be performed without any problem.

[0085] Furthermore, in the bending operations of the finger mechanisms 2a to 2e, even when any two of the finger mechanisms touch an object to be held or the like and thereby are disabled to bend further, the bending operations of the other finger mechanism can be performed. For example, when both the finger mechanisms 2c and 2d among the finger mechanisms 2b to 2e are disabled to bend, both the respective joining elements 32 and 33 can incline via the spindles 44 and 45 to absorb amounts in which the wires 29b and 30a cannot be pulled and move rearward while pulling the wires 29a and 30b. Meanwhile, as for the finger mechanism 2a, by the winding-up of the wire 31 around the winding-up shaft 58, the length of the part of the wire 31 from the pulley 34 to the tip end of the finger mechanism 2a is decreased, so that the bending operation of the finger mechanism 2a is performed. This is similar in a case where a pair of the finger mechanisms 2b and 2d, a pair of the finger mechanisms 2b and 2e, or a pair of the finger mechanisms 2c and 2e are disabled to bend.

[0086] Furthermore, in a case where the finger mechanism 2a and any one of the finger mechanisms 2b to 2e are disabled to bend, as in the above-mentioned cases, since the joining elements 32 and 33 can also move rearward together with the pulley 36, the other finger mechanisms can perform the bending operations by the winding-up of the wire 31 around the winding-up shaft 58.

[0087] Furthermore, in a case where a pair of the finger mechanisms 2b and 2c, or a pair of the finger mechanisms 2d and 2e are disabled to bend further, the other finger mechanisms can also perform the bending operations. For example, in the case where the pair of the finger mechanisms 2b and 2c are disabled to bend, since neither of the wires 30a and 30b can be pulled, the joining element 33 joined to the wires 30a and 30b cannot move rearward. On the other hand, the holding element 43 holding both of the joining elements 32 and 33 via the link elements 43a and 43b can absorb an amount in which the joining element 33 cannot move, by balance-like inclination via the spindle 42 to thereby move toward the rear side (the arm 5 side). Thereby, the joining element 32 joined to the wires 29a and 29b, which can be pulled, moves toward the rear side by the inclined holding element 43. In this way, even when the pair of the finger mechanisms 2b and 2c are disabled to bend, the bending operations of the other finger mechanisms 2a, 2d and 2e can be performed while winding up the wire 31 around the winding-up shaft 58 inside of the arm 5. This is similar in the case where the pair of the finger mechanisms 2d and 2e is disabled to bend.

[0088] Similarly, in a case where any three finger mechanisms of the finger mechanisms 2a to 2e are disabled to bend further, the two remaining finger mechanisms can also perform the bending operations, and furthermore, in a case where any four finger mechanisms of the finger mechanisms 2a to 2e are disabled to bend further, the bending operation of the one remaining mechanism can also be performed. In this case, in a case where the finger mechanism 2a and any three finger mechanisms of the finger mechanisms 2b to 2e are disabled to bend, basically, the one remaining finger mechanism can perform the bending operation by rocking the holding element 43. Furthermore, in a case where the four finger mechanisms 2b to 2e except for the finger mechanism 2a are disabled to bend, the holding element 43, the joining elements 32 and 33 supported pivotally by the same, and the pulley 36 are disabled to move rearward, however, by the winding-up of the wire 31 around the winding-up shaft 58, the length of the part of the wire 31 from the pulley 34 to the tip end of the finger mechanism 2a is decreased, so that the bending operation of the finger mechanism 2a is performed.

[0089] As described above, in the multi-finger hand device 1 according to the present embodiment, the wire 31 is wound up around the winding-up shaft 58 by the driving force of the single motor for finger driving 56, so that the bending operations of all the finger mechanisms 2a to 2e can be performed collectively. Accordingly, instead of providing the actuator for operating each of the finger mechanisms 2a to 2e, work such as holding an object not shown in the figure can be performed by the five finger mechanisms 2a to 2e with a small number of actuators. In addition, in this case, even when any of the finger mechanisms 2a to 2e touches an object or the like, and is disabled to bend further, since the bending operations of the other finger mechanisms can be performed, the holding of the object by the finger mechanisms 2a to 2e can be securely performed without any problem.

[0090] Incidentally, in the above-mentioned description, the bending operations of the finger mechanisms 2a to 2e from the stretching state are described, however, a similar effect can be brought about in the case where the finger mechanisms 2a to 2e are stretched from the bending state. Specifically, for example if a pulling force of the wire 31 (a winding-up force around the winding-up shaft 58) by the motor for finger driving 56 is released from the state in which the finger mechanisms 2a to 2e are bent, basically, the finger mechanisms 2b to 2c stretch by the biasing forces of the springs 16 corresponding to the respective finger mechanisms, while the finger mechanism 2a stretches by the biasing forces of the spring 26 and the other spring not shown in the figure. At this time, even if any of the finger mechanisms 2a to 2e touches an obstacle or the like and is disabled to stretch further, the other finger mechanisms 2a to 2e can stretch without any problem by the movement of the joining elements 32 and 33 and the pulley 36 in the anteroposterior direction, and the rocking of the holding element 43 holding the same.

[0091] Furthermore, in the multi-finger hand device 1 according to the present embodiment, by actuating the motor for hand rotation 55 inside of the arm 5, the hand 3 is rotated around the shaft center of the joining shaft 52 together with the joining shaft 52. At this time, since the wire 31 extending from the hand 3 side to the inside of the arm 5 extends along the shaft center of the joining shaft 52 which is a rotation shaft center of the hand 3, the hand 3 rotates without pulling the wire 31. Therefore, the hand 3 can be rotated with respect to the arm 5 without any problem, not affecting the bending and stretching state of the finger mechanisms 2a to 2e.

[0092] Furthermore, in the multi-finger hand device 1 according to the present embodiment, since the part on the tip end side from the second joint 11 of each of the finger mechanisms 2b to 2e except for the finger mechanism 2a (the part made of the second interjoint element 8, the third interjoint element 9, the third joint 12, and the link arm 15) is identical to each other in shape and size of the respective components, spares thereof can be shared by each other, and the number of types of components required for the multi-finger hand device 1 is reduced, which makes the component management easier.

[0093] Furthermore, in the multi-finger hand device 1 according to the present embodiment, with regard to each of the finger mechanisms 2b to 2e, through the link mechanism 13, by rotating the first interjoint element 7 closest to the hand 3 around the shaft center of the joint shaft 10a of the first joint 10 with respect to the fixing element 6, the second interjoint element 8 and the third interjoint element 9 conjunctionally rotate with respect to the first interjoint element 7 and the second interjoint element 8, respectively, so that the bending and stretching of each of the finger mechanisms 2b to 2e can be performed. Therefore, in the wires 29a and 29b, the length from the joining element 32 to fixing points with respect to the finger mechanisms 2d and 2e can be shortened, and similarly, in the wires 30a and 30b, the length from the joining element 33 to fixing points with respect to the finger mechanisms 2b to 2c can be shortened. Accordingly, the whole required length of these wires 29a, 29b, 30a and 30b is shortened, which is advantageous in view of cost.

[0094] Furthermore, in the multi-finger hand device 1 according to the present embodiment, since the hand 3 is electrically insulated with respect to the arm 5 as described above, even if the hand 3 is put into water, current flowing in the electrical components such as the motors 55 and 56 inside of the arm 5 does not leak to the hand 3 side. Consequently, the multi-finger hand device 1 allows the work of holding an object in water or the like to be performed without any problem.

[0095] Incidentally, the present invention is not limited to the above-mentioned embodiment, but for example, the following modified embodiment is also possible. According to the above-mentioned embodiment, although the finger mechanisms 2a to 2e are designed to be biased to the stretching side, they may be designed to be biased to the bending side. The embodiment of this case can be configured by changing the multi-finger hand device 1 according to the above-mentioned embodiment as follows, for example. Specifically, each of the finger mechanisms 2b to 2e comprising the link mechanism 13 is biased to the bending side of the respective finger mechanisms 2b to 2e, for example, by a power spring provided in the first joint 10 or the like instead of connecting the spring 16 to the first interjoint element 7. Then, the wires 29a, 29b, 30a and 30b extensionally provided from the first interjoint elements 7 of the respective finger mechanisms 2b to 2e are extended to the hand 3 side via the outer peripheries on the lower side of the corresponding guide pulleys 19 of the respective finger mechanisms 2b to 2e (the outer peripheries closer to the face portions on the back side of respective finger mechanisms 2b to 2e). Furthermore, the finger mechanism 2a is biased to the bending side, for example, by power springs provided in the first and second joints 23 and 24, respectively or the like, instead of biasing to the stretching side by the spring 26 and the other spring not shown in the figure. Then, a wiring route of the wire 31 inside of the finger mechanism 2a is adjusted so as to stretch the finger mechanism 2a when the wire 31 provided extensionally from the tip end of the finger mechanism 2a is pulled (for example, the wire 31 is wired so as to be taken along the face portion on the back side of the finger mechanism 2a).

[0096] The structures other than the foregoing may be identical to those of the multi-finger hand device 1 according to the above-mentioned embodiment. When the multi-finger hand device is configured in this manner, by pulling the wire 31 to the inside of the arm 5, the stretching operations of the finger mechanisms 2a to 2e are performed collectively. At this time, even if any of the finger mechanisms 2a to 2e touches an object or the like

and is disabled to stretch, the stretching operations of the remaining finger mechanisms can be performed by the actuation similar to that in the above-mentioned embodiment.

[0097] Furthermore, in the above-mentioned embodiment, the bending operations of the finger mechanisms 2a to 2e are performed by introducing the wire 31 joined to the finger mechanism 2a to the inside of the arm 3 and pulled by the motor for finger driving 56, however, by fixing the end of the wire 31 derived from the pulley 38 to the hand 3 and pulling an intermediate portion of the wire 31, the bending operations of the finger mechanisms 2a to 2e can also be performed. In this case, for example, the pulley 37 in the above-mentioned embodiment is held rotatably by the pulley holding member which is movable in the anteroposterior direction, and the wire element is drawn from this holding element 43 to the inside of the arm 5. Then, this wire element is pulled by the actuator provided inside of the arm 5, so that the bending operations of the finger mechanisms 2a to 2e can be performed.

[0098] Furthermore, according to the above-mentioned embodiment, the finger mechanisms 2b to 2e are provided with the link mechanisms 13, and by pulling the wires 29a, 29b, 30a, and 30b provided extensionally from the first interjoint elements 7 of the respective finger mechanisms 2b to 2e, and rotating the first interjoint elements 7 around the shaft center of the first joint shafts 10a of the first joints 10, the second interjoint elements 8 and 9 are conjunctionally rotated, so that the bending and stretching operations of the respective finger mechanisms 2b to 2e are performed, while it is also possible to perform the bending and stretching operations of the respective finger mechanisms 2b to 2e, for example, by pulling the wire elements provided extensionally from the second interjoint elements 8 of the respective finger mechanisms 2b to 2e to rotate the second interjoint elements 8. In this case, for example, one end of each of the wires 29a and 29b in the above-mentioned embodiment is fixed to the second interjoint element 8 of each of the finger mechanisms 2d and 2e at a position closer to the belly thereof, and one end of each of the wire 30a and 30b is fixed to the second interjoint element 8 of each of the finger mechanisms 2b and 2c at a position closer to the belly thereof. Then, by moving the joining elements 32 and 33 toward the rear side (the arm 5 side) to pull the wires 29a, 29b, 30a and 30b, the second interjoint element 8 and the first interjoint element 7 of each of the finger mechanisms 2b to 2e are rotated around the joint shafts of the second joint 11 and the third joint 12, respectively. Furthermore, the first interjoint element 7 and the third interjoint element 9 of each of the finger mechanisms 2b to 2e may be joined by the link arm 15 according to the above-mentioned embodiment so as to rotate the third interjoint element 9 around a shaft center of the joint shaft 12a of the third joint 12 in conjunction with the rotation of the second interjoint element 8.

[0099] Furthermore, in the above-mentioned embodiment, the multi-finger hand device 1 provided with the five finger mechanisms 2a to 2e to imitate a human hand is described, however, the present invention can naturally be applied to, for example, a multi-finger hand device provided with three or four finger mechanisms.

INDUSTRIAL APPLICABILITY

[0100] As described above, the present invention is useful as a hand device of a robot such as a humanoid, which performs various kinds of work by a plurality of finger mechanisms provided extensionally from a hand.

Claims

1. A multi-finger hand device comprising:

   a hand attached to a tip end of an arm;
   a plurality of finger mechanisms provided extensionally from the hand each of which is structured to sequentially connect a plurality of interjoint elements via finger joints;
   biasing means for biasing the respective finger mechanisms to any one of the stretching direction and the bending direction;
   wire elements provided extensionally from the respective finger mechanisms to the hand side; and
   driving means for performing bending operations or stretching operations of the finger mechanisms by pulling the wire elements provided extensionally from the respective finger mechanisms against biasing forces of the biasing means, wherein:

   the driving means comprises a joining element having a pair of joining portions which join ends on the hand side of the two wire elements provided extensionally from at least two finger mechanisms of the plurality of finger mechanisms respectively with a space left therebetween, and a holding element which rockably holds the joining element via a supporting point provided between both the joining portions of the joining element and can move in a pulling direction of the two wire elements; and when the bending operations or the stretching operations of the two finger mechanisms are performed, the wire elements provided extensionally from the two finger mechanisms are pulled by moving the holding element.

2. A multi-finger hand device comprising:

a hand attached to a tip end of an arm;
at least four or more finger mechanisms provided extensionally from the hand each of which is structured to sequentially connect a plurality of interjoint elements via finger joints;
biasing means for biasing the respective finger mechanisms to any one of the stretching direction and the bending direction;
wire elements provided extensionally from the respective finger mechanisms to the hand side; and
driving means for performing bending operations or stretching operations of the finger mechanisms by pulling the wire elements provided extensionally from the respective finger mechanisms against biasing forces of the biasing means, wherein;
the driving means comprises two joining elements each having a pair of joining portions wherein at least four finger mechanisms of the plurality of finger mechanisms are classified into two pairs and the joining portions join ends on the hand side of the two wire elements provided extensionally from the two finger mechanisms of each of the two pairs with a space left therebetween, and a holding element which rockably holds the two joining elements with a space left therebetween via supporting points each provided between both the joining portions in each of the joining elements and can move in a pulling direction of the wire elements provided extensionally from the four finger mechanisms respectively and can rock around a supporting point provided between the two joining elements; and when the bending operations or the stretching operations of the four finger mechanisms are performed, the wire elements provided extensionally from the four finger mechanisms are pulled by moving the holding element.

3. The multi-finger hand device according to claim 1, comprising at least three or more said finger mechanisms, wherein:

the driving means comprises a pulley element onto which the wire element provided extensionally from the one finger mechanism other than the two finger mechanisms is wound and which is held rotatably by the holding element; and when the bending operations or the stretching operations of the two finger mechanisms and the one other finger mechanism are performed, the wire element provided extensionally from the one other finger mechanism is pulled in such a direction that the pulley element moves in a pulling direction of the wire elements provided extensionally from the two finger mechanisms together with the holding element.

4. The multi-finger hand device according to claim 2, comprising at least five or more said finger mechanisms, wherein:

the driving means comprises a pulley element onto which the wire element provided extensionally from the one finger mechanism other than the four finger mechanisms is wound and which is held rotatably by the holding element between the two joining elements; and when the bending operations or the stretching operations of the four finger mechanisms and the one other finger mechanism are performed, the wire element provided extensionally from the one other finger mechanism is pulled in such a direction that the pulley element moves in a pulling direction of the wire elements provided extensionally from the four finger mechanisms together with the holding element.

5. The multi-finger hand device according to claim 2, wherein the supporting point provided between the two joining elements is located closer to any one of the joining elements.

6. The multi-finger hand device according to any one of claims 1 to 5, wherein the supporting point provided between both the joining portions of the joining element is located closer to any one of the joining portions.

7. The multi-finger hand device according to any one of claims 1 to 5, wherein the joining element is held by the holding element via a link element provided consecutively and rockably to the holding element.

8. The multi-finger hand device according to any one of claims 1 to 5, wherein at least one finger mechanism of the plurality of the finger mechanisms has a link mechanism joined to the plurality of interjoint elements of the finger mechanism, so that rotational operations around the other finger joints are performed in conjunction with a rotational operation of the interjoint element continued into the finger joint closest to the hand around the finger joint, and the wire element provided extensionally from the finger mechanism is provided extensionally from the interjoint element closest to the hand.

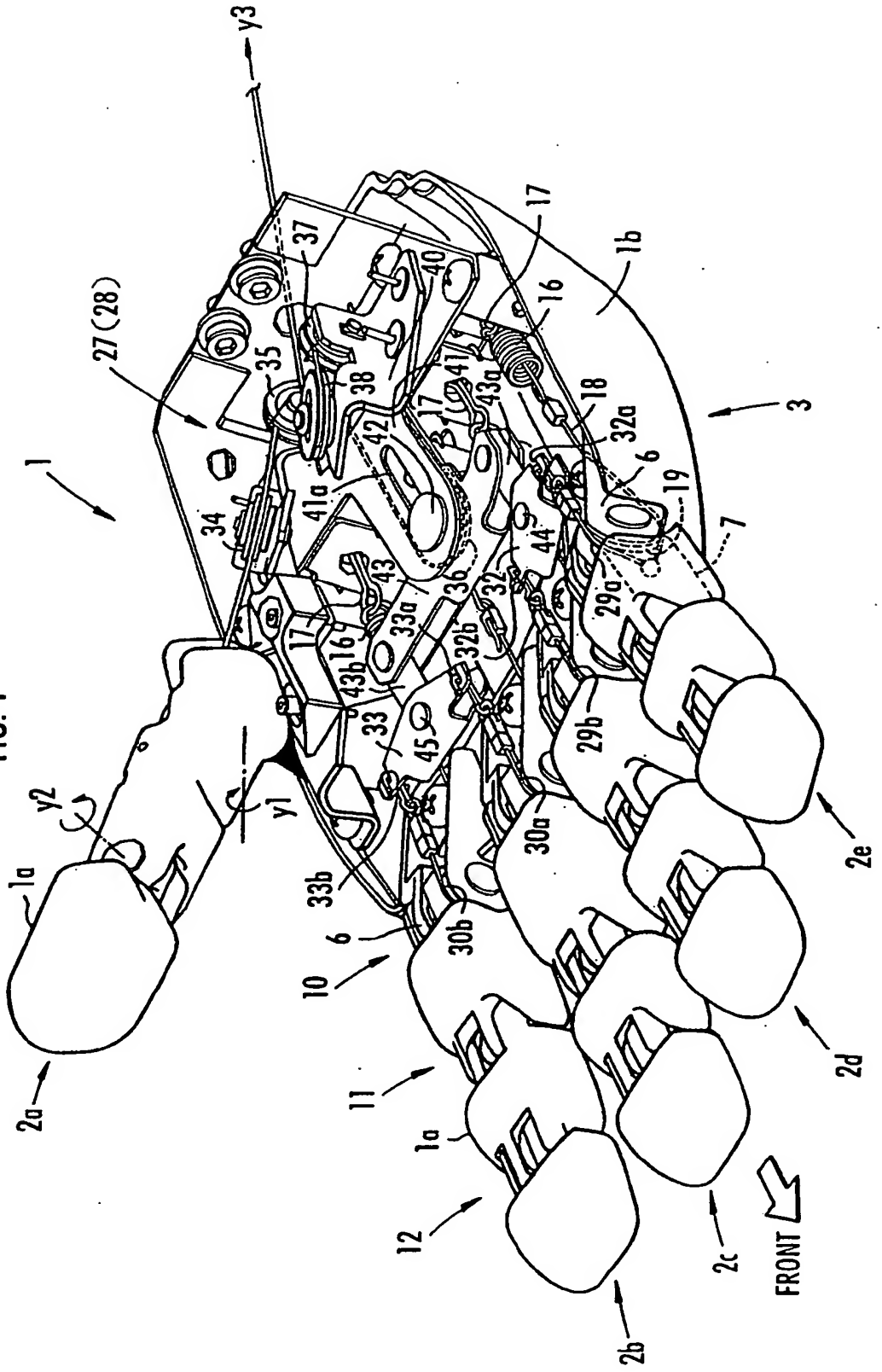
9. The multi-finger hand device according to any one of claims 1 to 5, wherein the two or more interjoint elements of each of the two or more finger mechanisms among the plurality of finger mechanisms have an identical structure.

10. The multi-finger hand device according to any one of claims 1 to 5, wherein:

the hand is provided rotatably around a shaft center extending in a substantially longitudinal direction of the arm;
the driving means comprises at least one driving wire element provided extensionally from the hand to the inside of the arm, and an actuator for applying to the driving wire element a driving force for pulling the driving wire element toward the inside of the arm, the driving means transmitting the force of pulling the wire elements provided extensionally from the respective finger mechanisms from the actuator to the hand side via the driving wire element; and
the driving wire element is arranged into the arm along the rotation shaft center of the hand.

11. The multi-finger hand device according to claim 10, wherein the arm and the hand are insulated electrically, and the driving wire element is formed of an insulating material.

FIG. 1


y3
27(28)
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y2
y1
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2b
2c
2d
2e
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1b
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6
7
16
17
18
19
29a
29b
30a
30b
32
32a
32b
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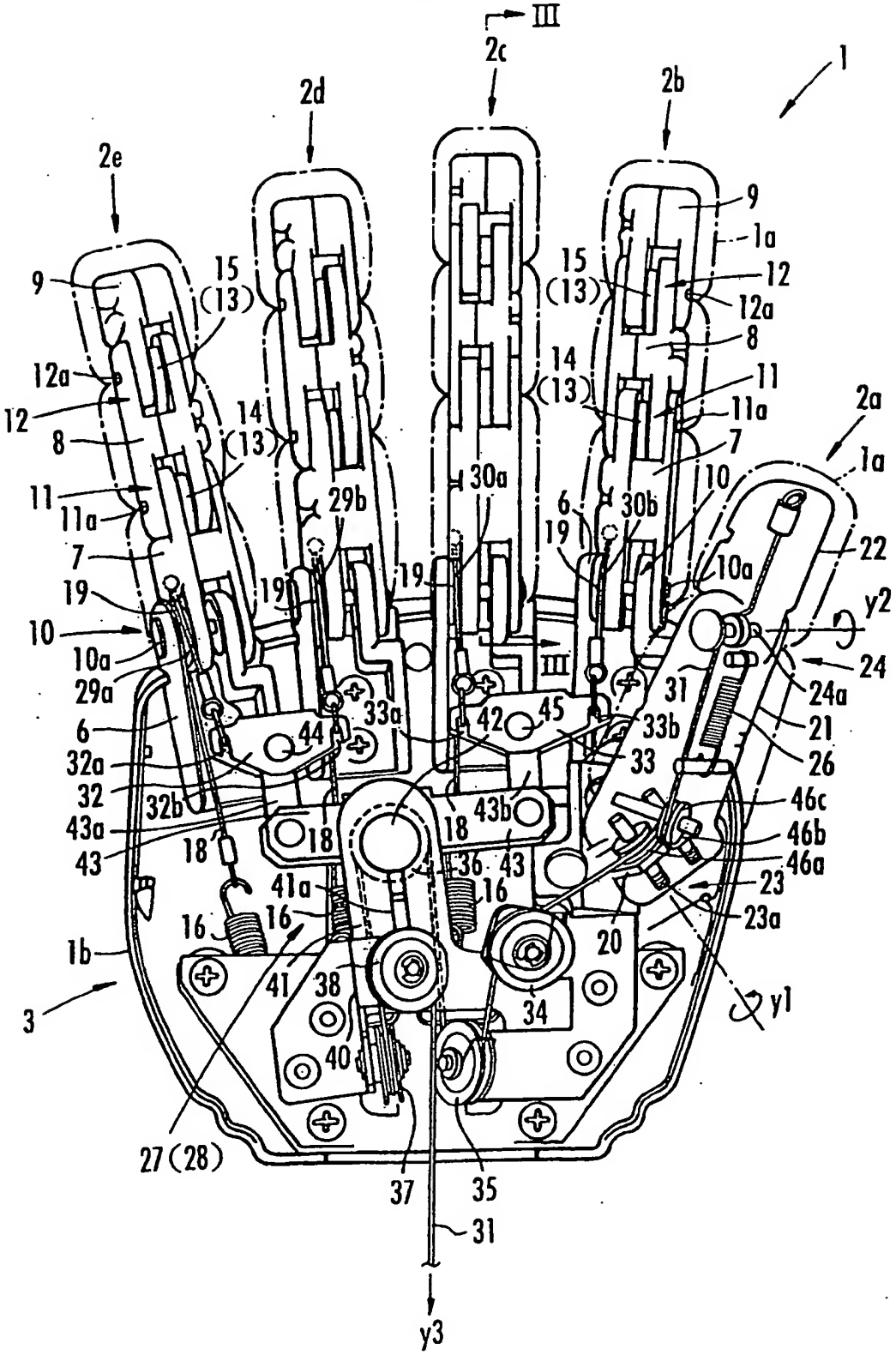
43b
44
45

FIG. 2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46c
46b
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23a
y1
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33b
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44
33a
32a
32
32b
43a
43
43b
36
41a
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31
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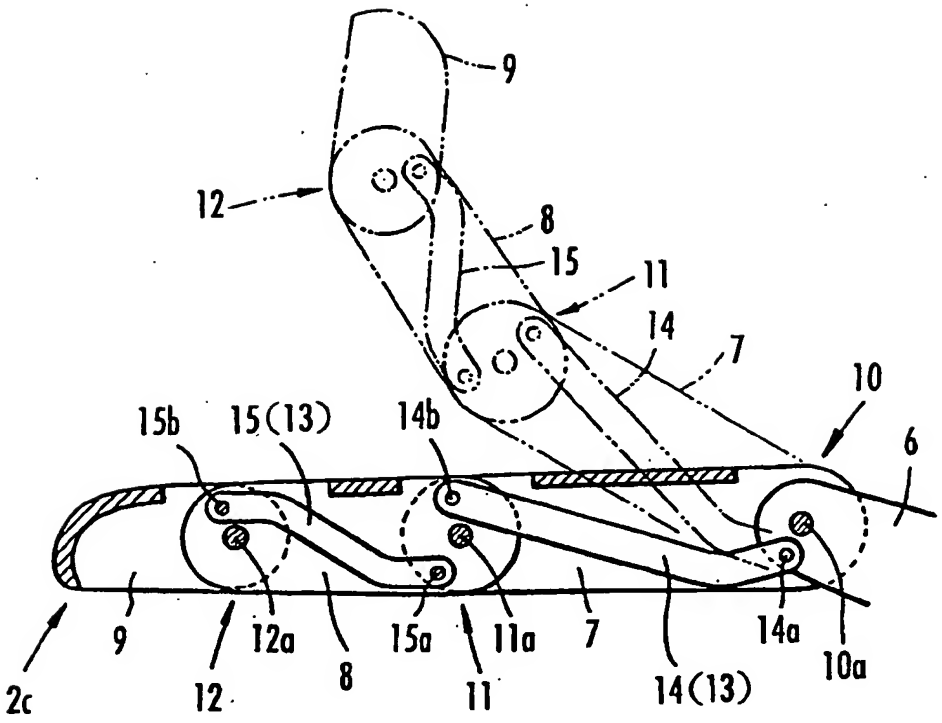
30a
30b

FIG. 3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15(13)
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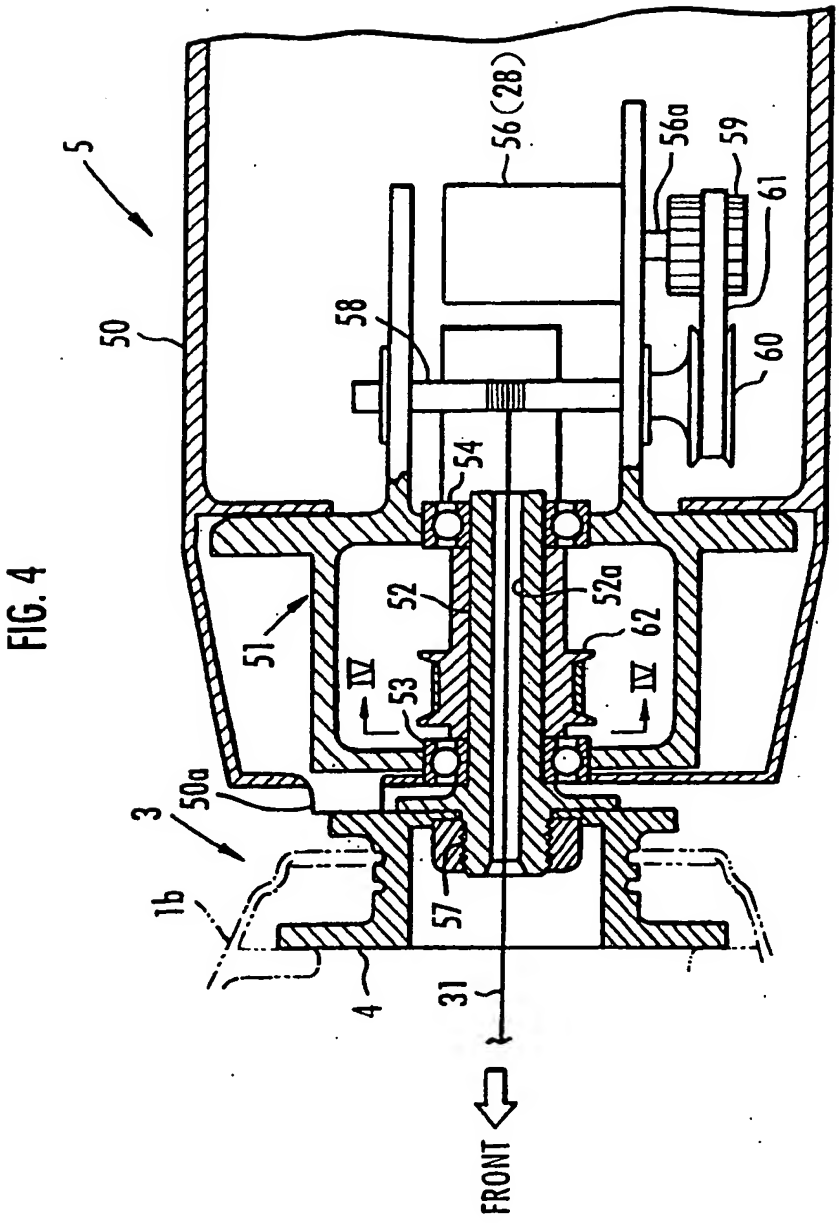
11a
7
14(13)
14a
10a

FIG. 4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56(28)
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1b
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31
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FIG. 5

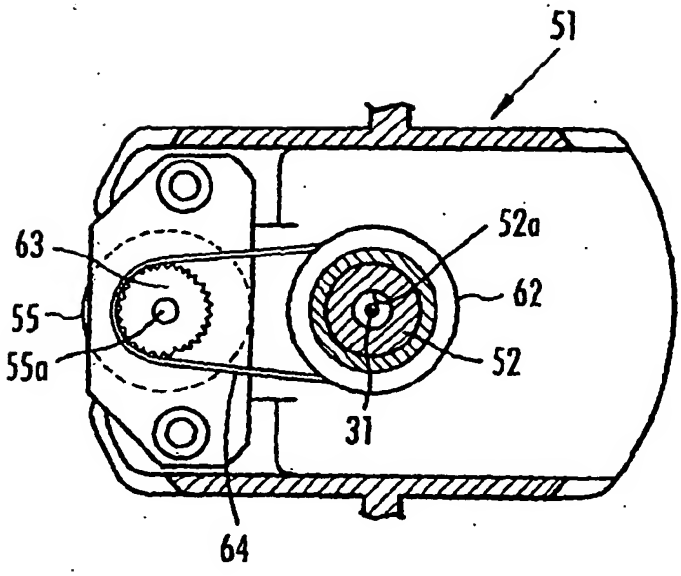
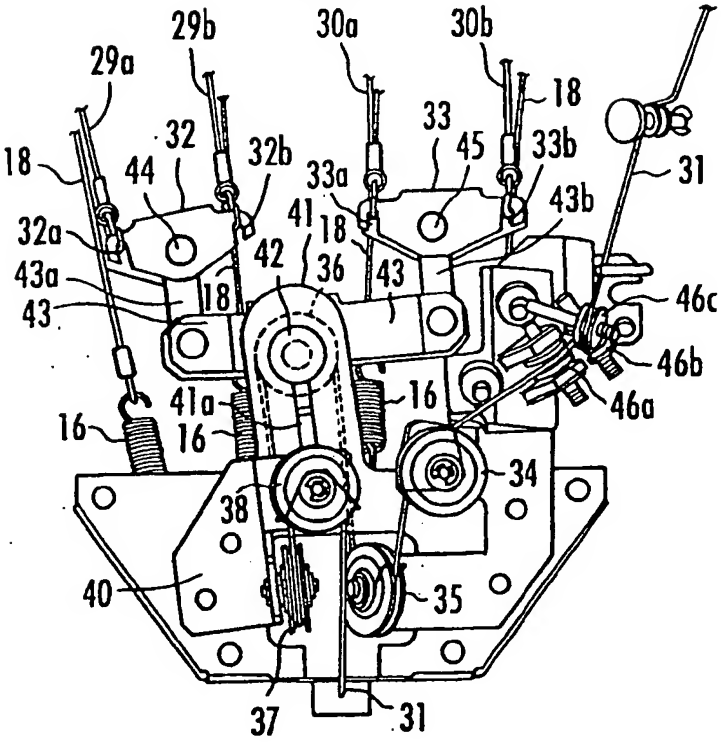


FIG. 6 (a)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42
36
43
43a
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46b
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46a
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16
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38
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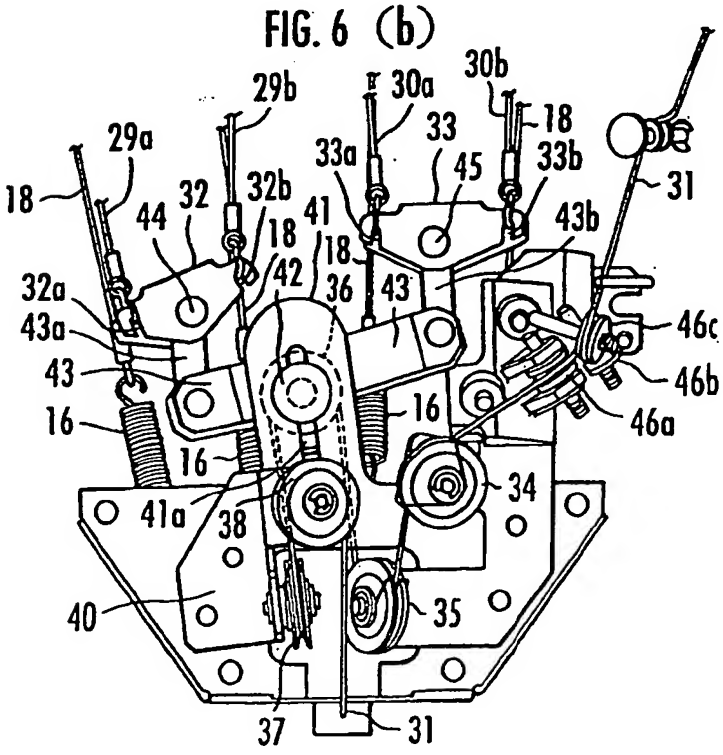
31

FIG. 6 (b)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32b
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43b
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36
43
32a
43a
46c
43
46b
16
16
46a
16
34
41a
38
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37
31

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP02/08570

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] B25J15/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] B25J15/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1926-1996	Toroku Jitsuyo Shinan Koho	1994-2002
Kokai Jitsuyo Shinan Koho	1971-2002	Jitsuyo Shinan Toroku Koho	1996-2002

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 50-28551 Y1 (Omron Tateisi Electronics Co.), 22 August, 1975 (22.08.75), Claims; Figs. 1 to 5 (Family: none)	1,6,8-11 2-5,7
Y A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 7852/1978 (Laid-open No. 112282/1979) (Komatsu Ltd.), 07 August, 1979 (07.08.79), Claims; Figs. 1 to 6 (Family: none)	1,6,8-11 2-5,7
Y A	JP 55-25986 Y2 (Tomy Kogyo Kabushiki Kaisha), 23 June, 1980 (23.06.80), Claims; Figs. 1 to 3 (Family: none)	1,6,8-11 2-5,7

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 November, 2002 (25.11.02)	10 December, 2002 (10.12.02)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP02/08570

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 50-32927 Y1 (Ishikawajima-Harima Heavy Industries Co., Ltd.), 25 September, 1975 (25.09.75), Claims; Figs. 1 to 3 (Family: none)	8
Y	JP 63-251186 A (Fujitsu Ltd.), 18 October, 1988 (18.10.88), Claims; Figs. 1 to 9 (Family: none)	8
Y	JP 8-300282 A (Aichi Corp.), 19 November, 1996 (19.11.96), Claims; Figs. 1 to 2 (Family: none)	11
Y	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 71875/1992 (Laid-open No. 31983/1994) (Aichi Corp.), 26 April, 1994 (26.04.94), Claims; Figs. 1 to 2 (Family: none)	11

EUROPEAN PATENT OFFICE

Patent Abstracts of Japan

PUBLICATION NUMBER : 11156778
PUBLICATION DATE : 15-06-99

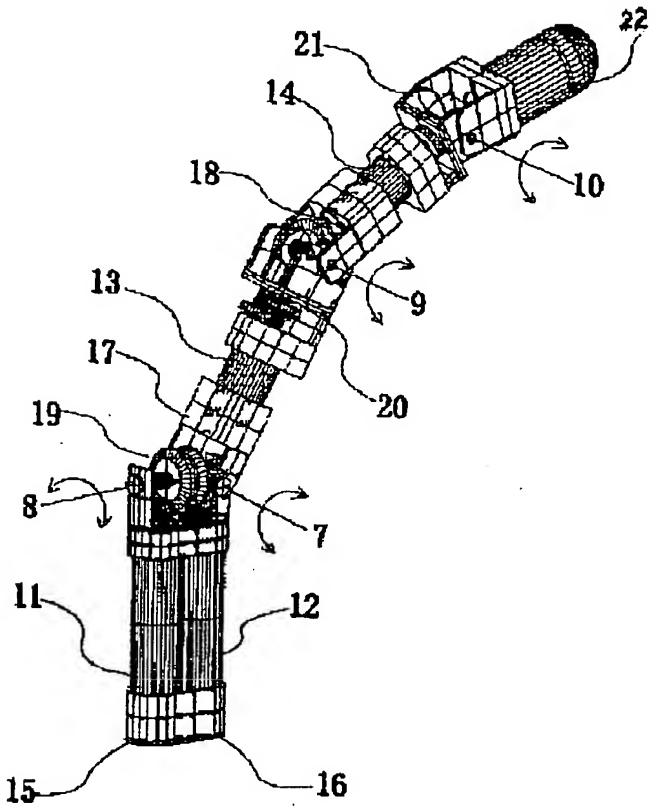
APPLICATION DATE : 07-08-97
APPLICATION NUMBER : 09213173

APPLICANT : GIFU PREFECTURE KENKYU KAIHATSU ZAIDAN;

INVENTOR : KOMATSU TSUNEO;

INT.CL. : B25J 15/08

TITLE : ROBOT HAND



ABSTRACT : PROBLEM TO BE SOLVED: To enable the same movement as human fingers by enhancing the degree of freedom of fingers by orthogonally crossing two joint shafts on the root side of each finger at a point and independently driving the two joints by providing two motors on the palm.

SOLUTION: A joint shaft 7 and a joint shaft 8 are crossed at a point and are orthogonally crossed. A motor 11 and a motor 12 are fixed by being overlapped on the palm. Further, the structure is made to have a mechanism in which revolution around the joint shaft 8 and revolution around the joint shaft 7 are made possible by a bevel gear at the inside of an asymmetric differential reduction gear 19. When the motor 11 and the motor 12 perform the same angle revolution in each opposite direction, fingers revolve around the joint shaft 8 via the bevel gear at the inside of the asymmetric differential reduction gear 19. When the motor 11 is fixed and the motor 12 is revolved, the fingers revolve around the joint shaft 7. Because the joint shafts 7 and 8 are provided at the locations near the surface side of the palm, movement similar to the movement of the human hands can be made.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the mechanism composition in a human-being type (hyperdactyly many joints) robot hand similar to the shape of human being's hand.
[0002]
[The outline and its problem of a Prior art] As a conventional human-being type robot hand, "Literature Roderic A. grupen,et.al.,A survey of general-purpose manipulation, International Journal of Robotics. Researches, Vol. 8, and the Utah/MIT hand indicated to No.1-1989" are known well. This hand installs the motor for which each finger drives those with 4 joints, and each knuckle with 4 fingers in a fixed side, and the transmitting power between a motor and a knuckle has a complicated structure through a wire rope. Although the shape of the hand was similar to human being's hand, since the motor was installed in the fixed side, when a hand was attached at the tip of the arm of a robot, movement of the robot was restrained greatly.
[0003]Literature "M. E.Rosheim and Robot. evolution and John Wiley. &. Sons, Inc., To 1994." The indicated Omni hand. "Literature R. Tomovic rt. al., Astrategy for grasp synpaper with multifingered robot hand, IEEE international Conference on. Although Robotics and Automation, pp.83-89, and the Belgrade/USC hand of 1987" have structure which carries the motor which drives a joint in a hand and does not pass a wire rope, As for the joint number of each finger, four joints do not have the former like the finger of 3 and human being, and there are only the latters of only four flexibility on the whole for the composition in which each finger drives the whole hand by four motors with five fingers although indices are four joints. For this reason, each finger was difficult for movement which each [with 4 joints] finger was not devised as for the mechanism of 3 or more flexibility, but was similar to human being's hand like human being's finger.
[0004]"Literature Li-Ren Lin and Han=pang Hung, Integrating Fuzzy Control ofthe Dexterous National Taiwan University(NTUHand, IEEE/ASMW Tranzaction on Mechatronics, Vol. 1, No.3, pp.216-229, and the NTU hand of 1996" carry a motor, and the thumb and an index finger other fingers by four joints with 5 fingers 3 joint ****, There are the first joint and the second joint of the Nemoto part of a finger, and they do not lie at right angles to the position of torsion. On the other hand, as for human being's finger, the first joint and the second joint lie at right angles mostly. For this reason, human being's finger and similar movement are difficult.
[0005]In the robot hand which builds in the conventional motor as mentioned above, there is little flexibility of a finger, or there is nothing that two joints by the side of the origin intersected perpendicularly and provided by one point, and a motion which is different from movement of human being's finger for this reason was carried out.
[0006]
[Means for Solving the Problem]A robot hand concerning this invention arranges in the palm a motor which an axis of two joints by the side of the origin of a finger is made to intersect

perpendicularly by one point, and drives those joints, and it forms it so that driving force of a motor may be told to a joint via unsymmetrical differential reduction gears.

[0007]In this invention, since it can rotate by a circumference of two axes can build a motor which drives a joint of a finger in a hand, and axes and the Nemoto part of a finger cross at right angles, the same motion as human being's finger is possible.

[0008]

[Example](1) Drawing 1 of composition is one example of this invention, Drawing 2 is a detail view of the thumb and Drawings 3 are a detail view of unsymmetrical differential reduction gears, and a detail view of the finger of others [Drawing / 4] other than the thumb. in these figures -- 1 -- the thumb and 2 -- an index finger and 3 -- the middle finger and 4 -- the ring finger and 5 -- a digitus minimus and 6 -- a palm and 7 -- the 1st joint of the procurvation, and 8 -- as for the 3rd joint of the procurvation, and 10, the 2nd motor and 13 the 3rd motor and 14 the 4th motor the 1st motor and 12 for the 4th joint of the procurvation, and 11 the 2nd joint of inner abduction, and 9, 15 -- the encoder for the 1st motor, and 16 -- as for asymmetrical type differential reduction gears and 20, the encoder for the 3rd motor and 18 are [a worm reducer and 22] 6 axis sense-of-force sensors articulated-axis integral-type reduction gears and 21 the encoder for the 4th motor, and 19 the encoder for the 2nd motor, and 17. 23 to 27 is the 5th bevel gear from the 1st bevel gear, and 28 is the Section 4 link mechanism.

(2) The example of ****** is a robot hand of 5 fingers similar to human being's hand, and shows the operation below.

[0009]The rotation of each motor of 11 to 14 is detectable with the encoder for motors of 15 to 18 linking directly to a motor shaft. The axis of each joint of 7, 9, and 10 is parallel respectively, and the articulated axis of 7 and the articulated axis of 8 cross and lie at right angles by one point. The 1st motor of 11 and the 2nd motor of 12 are fixed to the palm of 6 in piles. The operation of the thumb of 1 is as follows. By the 4th motor of 14, the articulated axis of 10 which carried out axial rotation 90 degrees with the motor shaft via the worm reducer of 21 can be driven. By the 3rd motor of 13, the articulated axis of 9 which carried out axial rotation 90 degrees with the motor shaft via the articulated-axis integral-type reduction gears of 20 can be driven. In the asymmetrical type differential reduction gears of 19, it is a mechanism in which rotation of the circumference of the axis of the 2nd joint of 8 and rotation of the circumference of the axis of the 1st joint of 7 are possible by making the axis of the 3rd bevel gear of 25 hollow, and making the axis of the 4th bevel gear of 26 penetrate. here, they of the 1st motor of 11 and the 2nd motor of 12 are the same as that of a reverse direction -- if angle rotation is carried out, a finger will rotate by the circumference of the axis of the 2nd joint of 8 via the bevel gear inside the asymmetrical type differential reduction gears of 19. If the 1st motor of 11 is fixed and the 2nd motor of 12 is rotated, a finger will rotate around the first articulated axis of 7. Since angle of rotation of the circumference of the articulated axis of 7 can take greatly by adoption of the asymmetrical type differential reduction gears of 19 and an articulated axis can be provided in the position near the surface side of the palm of 6, an exterior can also perform the motion similar to a motion of human being's hand.

[0010]The place where the index finger of 2, the middle finger of 3, the ring finger of 4, and the digitus minimus of 5 differ from the thumb of 1 is the point is interlocked with the motor of 13 via the Section 4 link mechanism of 28 in the 4th articulated axis of 10, and it was made to move. Therefore, the 3rd joint of 9 and the 4th joint of 10 can be simultaneously rotated in the same direction by the 3rd motor of 13.

[0011]

[Effect of the Invention]By such composition, as for the thumb, the finger of those with 4 joint 4 flexibility and others serves as 4 joint 3 flexibility. furthermore -- the axis of the 1st joint and the 2nd joint in the Nemoto part of each finger intersects perpendicularly -- and the 2nd joint of 7 -- a palm -- since it is set to the side, similar movement can be performed with human being's finger. Although the 3rd joint and the 4th joint interlock and human being's finger moves

13 and this mechanism also moves, similar movement can be performed with human being's finger.

[0012]In the example of this invention, although it is considered as 5 fingers, it is not necessarily limited to 5 fingers, and the robot hand of 3-5 finger can be carried out similarly. Although the thumb was made into 4 joint 4 flexibility, it has the same composition as other fingers, and the robot hand of 4 joint 3 flexibility can also be carried out.

[Translation done.]

(19)日本国特許庁（ＪＰ）　(12)公開特許公報（Ａ）　(11)特許出願公開番号

特開平11－156778

(43)公開日　平成11年(1999)６月15日

(51)Int.Cl.[6]	識別記号	ＦＩ	
Ｂ２５Ｊ　15/08		Ｂ２５Ｊ　15/08	Ｊ
			Ｋ

審査請求　有　　請求項の数２　ＯＬ　（全　５　頁）

(21)出願番号　特願平9－213173

(22)出願日　平成９年(1997)８月７日

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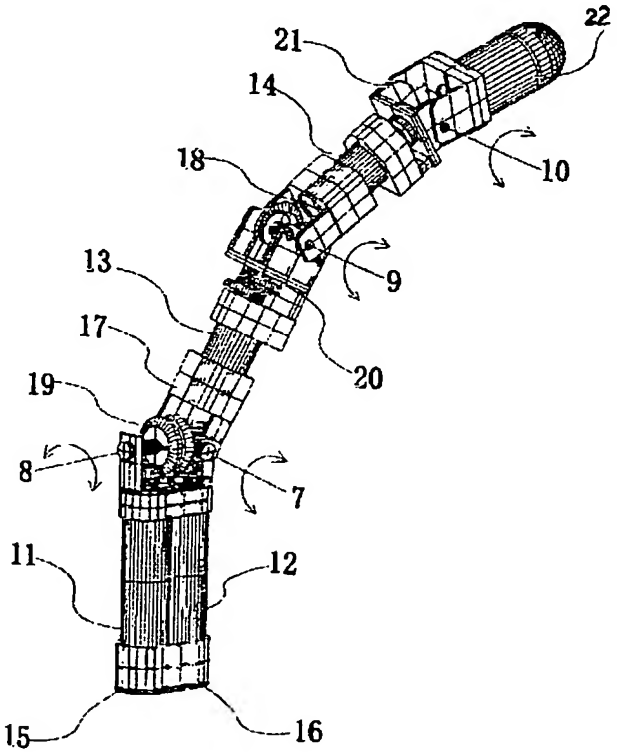
最終頁に続く

(54)【発明の名称】　ロボットハンド

(57)【要約】
【課題】　モータを内蔵し，人間の手と類似した運動ができるロボットハンド構造を得る。
【解決手段】　指の根本側の７の第１関節と８の第２関節の軸が１点で直交し，その２つの関節を独立に駆動できるように１つの指について１１の第１モータと１２の第２モータの２つのモータを掌に設け，それらの２つのモータとの間に１９の非対称差動減速機構を構成する。



【特許請求の範囲】

【請求項1】　4関節の指を複数配置し，各関節を駆動するモータを内蔵したロボットハンドにおいて，各指の根本側の第1関節と第2関節の軸が1点で直交し，その2つの関節を独立に駆動できるように1つの指について2つのモータを掌に設けたことを特徴とするロボットハンド。

【請求項2】　指の根本側の第1関節と第2関節を駆動する2つのモータとの間に，非対称差動減速機構を設けたことを特徴とする請求項1記載のロボットハンド。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は，人間の手の形状に類似した人間型（多指多関節）ロボットハンドにおける機構構成に関するものである。

【0002】

【従来の技術の概要とその問題点】従来の人間型ロボットハンドとして，文献「Roderic A. grupen,et.al.,A survey of general-purpose manipulation, International Journal of Robotics Researches, Vol. 8, No.1,1989」に記載されたUtah/MITハンドがよく知られている。本ハンドは，4本指で各指は4関節あり，各指関節を駆動するモータを固定側に設置し，モータと指関節の間の動力伝達は，ワイヤーロープを介する複雑な構造となっている。ハンドの形状は，人間の手に類似しているが，モータが固定側に設置されているため，ロボットのアームの先端にハンドを取り付けたとき，ロボットの運動が大きく制約されていた。

【0003】文献「M.E.Rosheim, Robot evolution,John Wiley & Sons, Inc., 1994」に記載されたOmniハンドと文献「R. Tomovic rt. al., Astrategy for grasp synpaper with multifingered robot hand, IEEE international Conference on Robotics and Automation, pp.83-89, 1987」のBelgrade/USCハンドは，関節を駆動するモータをハンドに搭載しワイヤーロープを介さない構造となっているが，前者は各指の関節数は3と人間の指のごとく4関節はなく，後者は指数は5指で各指は4関節であるがハンド全体をモータ4個で駆動する構成のため全体で4自由度しかない。このため，人間の指のように各指が4関節あり各指が3自由度以上の機構は考案されておらず，人間の手に類似した運動は困難であった。

【0004】また，文献「Li-Ren Lin and Han=pang Hung, Integrating Fuzzy Control ofthe Dexterous National Taiwan University(NTU)Hand, IEEE/ASMW Tranzaction on Mechatronics, Vol. 1, No.3, pp.216-229, 1996」のNTUハンドは，モータを搭載し，5本指で母指と示指は4関節で他の指は3関節あるが，指の根本部の第一関節と第二関節がねじれの位置にあって直交していない。一方，人間の指は第一関節と第二関節はほぼ直交している。このため，人間の指と類似した運動が困難である。

【0005】以上のように従来のモータを内蔵するロボットハンドでは，指の自由度が少なかったり，根本側の2つの関節が1点で直交して設けたものはなく，このため人間の指の運動と異なる動きをしていた。

【0006】

【問題点を解決するための手段】この発明にかかるロボットハンドは，指の根本側の二つの関節の軸を一点で直交するようにし，かつそれらの関節を駆動するモータを掌に配置し，モータの駆動力を非対称差動減速機を介して関節に伝えるよう設けるようにしたものである。

【0007】この発明において，指の関節を駆動するモータをハンドに内蔵でき，かつ指の根本部が直交する2つの軸まわりで回転できるため，人間の指と同様な動きが可能である。

【0008】

【実施例】（1）構成

第1図は本発明の一実施例であり，第2図は母指の詳細図，第3図は非対称差動減速機の詳細図，第4図は母指以外の他の指の詳細図である。これらの図において，1は母指，2は示指，3は中指，4は環指，5は小指，6は掌，7は前屈の第1関節，8は内外転の第2関節，9は前屈の第3関節，10は前屈の第4関節，11は第1モータ，12は第2モータ，13は第3モータ，14は第4モータ，15は第1モータ用エンコーダ，16は第2モータ用エンコーダ，17は第3モータ用エンコーダ，18は第4モータ用エンコーダ，19は非対称型差動減速機，20は関節軸一体型減速機，21はウオーム減速機，22は6軸力覚センサーである。23から27は第1傘歯車から第5傘歯車，28は4節リンク機構である。

（2）作用

この実施例は，人間の手に類似した5本指のロボットハンドであり，以下にその動作を示す。

【0009】11から14の各モータの回転量はモータ軸に直結した15から18のモータ用エンコーダにて検出できる。7，9，10の各関節の軸はそれぞれ平行であり，7の関節軸と8の関節軸は1点で交差し直交している。11の第1モータと12の第2モータは，6の掌に重ねて固定している。1の母指の動作はつぎのとおりである。14の第4モータにより，21のウオーム減速機を介してモータ軸と90度軸回転した10の関節軸を駆動できる。13の第3モータにより，20の関節軸一体型減速機を介してモータ軸と90度軸回転した9の関節軸を駆動できる。19の非対称型差動減速機では，25の第3傘歯車の軸を中空とし，26の第4傘歯車の軸を貫通させることにより，8の第2関節の軸まわりの回転と7の第1関節の軸まわりの回転が可能な機構となっている。ここで，11の第1モータと12の第2モータは，それらが逆の方向に同じ角度回転すると，19の非

対称型差動減速機内部の傘歯車を介して，８の第２関節の軸まわりで指が回転する。また，１１の第１モータを固定し，１２の第２モータを回転させると７の第一関節軸のまわりで指が回転する。また，１９の非対称型差動減速機の採用により７の関節軸まわりの回転角度が大きくとることができ，かつ，６の掌の表面側に近い位置に関節軸を設けられるため，外観上も人間の手の動きに似た動きができる。

【００１０】２の示指，３の中指，４の環指，および５の小指が，１の母指と異なるところは，１０の第４関節軸を２８の４節リンク機構を介して１３のモータと連動して動くようにした点である。したがって，１３の第３モータにより９の第３関節と１０の第４関節を同時に同じ方向に回転できる。

【００１１】

【発明の効果】このような構成により，母指は４関節４自由度あり，その他の指は４関節３自由度となっている。さらに，各指の根本部にある第１関節と第２関節の軸は直交し，かつ７の第２関節が掌側に設定されているので，人間の指と類似した運動を行えうる。人間の指は母指を除き第３関節と第４関節は連動して動くが，本機構も１３のモータにより９の第３関節と１０の第４関節が連動して動くので，人間の指と類似した運動ができる。

【００１２】本発明の実施例では，５本指としたが必ずしも５本指に限定されるものでなく，３～５本指のロボットハンドも同様に実施できる。さらに，母指を４関節４自由度としたが他の指と同一の構成とし４関節３自由度のロボットハンドも実施できる。

【図面の簡単な説明】

【図１】本発明の一実施例

【図２】母指の詳細図

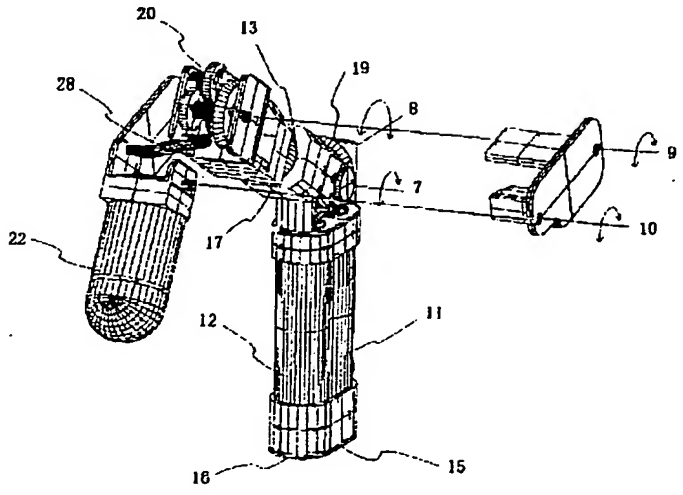
【図３】非対称差動減速機の詳細図

【図４】母指以外の他の指の詳細図

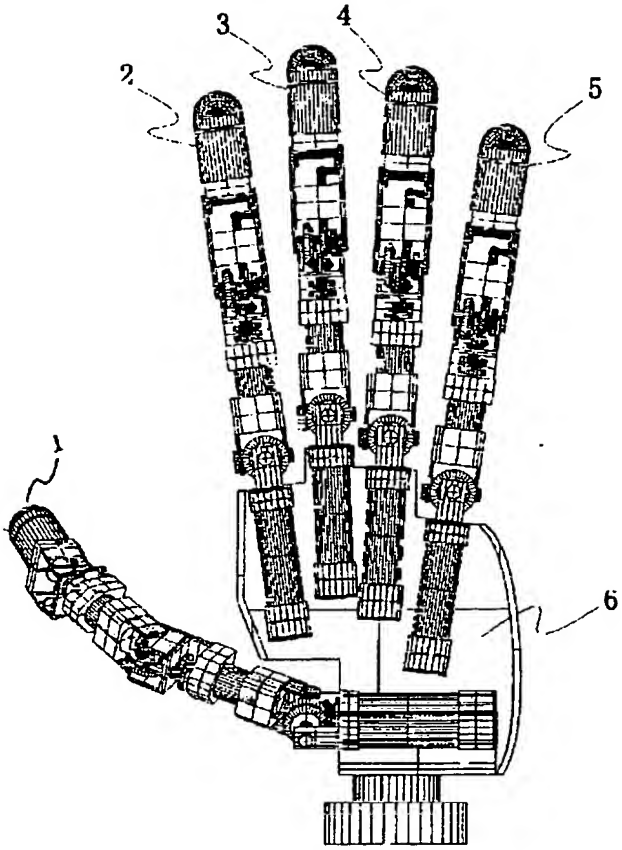
【符号の説明】

１	母指
２	示指
３	中指
４	環指
５	小指
６	手のひら
７	前屈の第１関節
８	内外転の第２関節
９	前屈の第３関節
１０	前屈の第４関節
１１	第１モータ
１２	第２モータ
１３	第３モータ
１４	第４モータ
１５	第１モータ用エンコーダ
１６	第２モータ用エンコーダ
１７	第３モータ用エンコーダ
１８	第４モータ用エンコーダ
１９	非対称型差動減速機
２０	傘歯減速機
２１	ウオーム減速機
２２	６軸力覚センサー
２３	第１傘歯車
２４	第２傘歯車
２５	第３傘歯車
２６	第４傘歯車
２７	第５傘歯車
２８	４節リンク機構

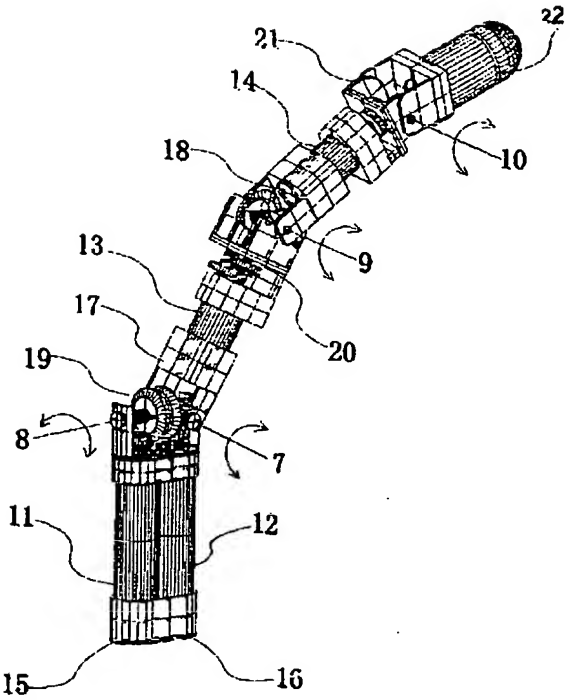
【図４】



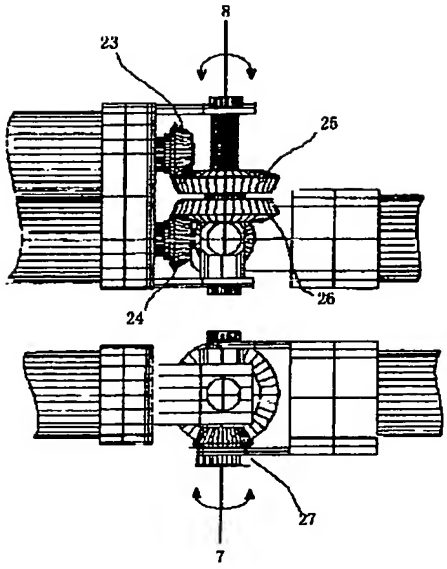
【図1】



【図2】



【図3】



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EUROPEAN PATENT OFFICE

R4

Patent Abstracts of Japan

PUBLICATION NUMBER : 2003117873
PUBLICATION DATE : 23-04-03

APPLICATION DATE : 15-10-01
APPLICATION NUMBER : 2001316828

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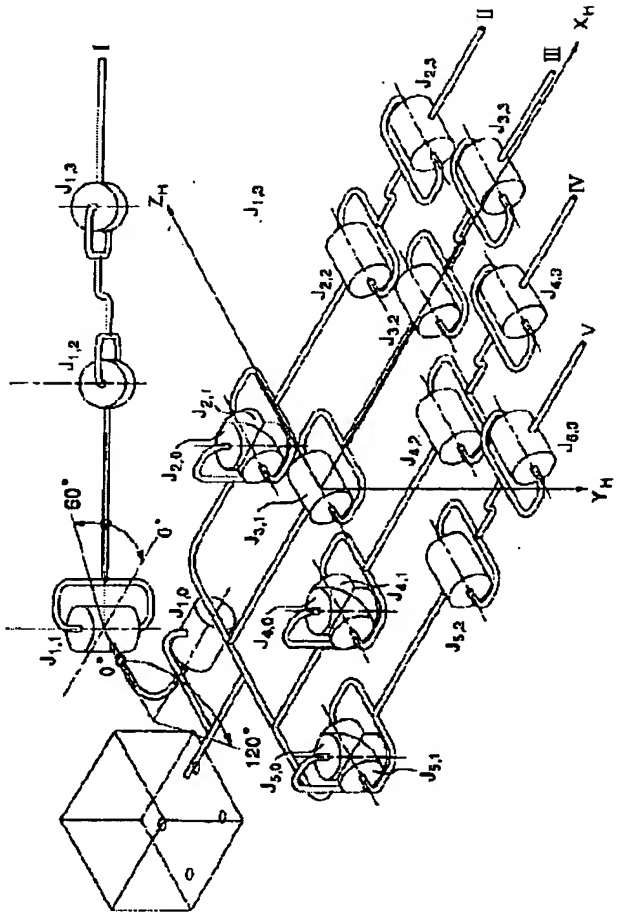
INT.CL. : B25J 15/08

TITLE : HUMAN BODY TYPE ROBOT HAND



ABSTRACT : PROBLEM TO BE SOLVED: To provide a human body type robot hand having a bending and stretching function of each finger, a moving function facing a thumb to other fingers, and an opening/closing (abduction) function between fingers.

SOLUTION: This human body type robot hand comprises 5 finger mechanisms, corresponding to five fingers of human being, and a palm portion corresponding to a palm and supporting the five finger mechanisms. The movement of the first finger mechanism corresponding to the thumb has three degrees of freedom, and the bending and stretching of each of the other second to fifth fingers has one degree of freedom. Abduction between the latter four fingers has one degree of freedom. The human body type robot hand has total eight degrees of freedom.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the person type robot hand provided with the expansion-and-contraction function of each finger, the motor function which carries out the thumb for making it face other fingers, and the opening-and-closing (abduction; abduction) function of fingers.
[0002]
[Description of the Prior Art]Like pen **** or sign language, the opening-and-closing (abduction; abduction) function of the expansion-and-contraction function of each finger and the motor function which carries out the thumb for making it face other fingers being not only required but fingers is required in the person type robot hand which needs movement of a wide range fine and fingertip.
[0003]
[Problem(s) to be Solved by the Invention]Although ** and front 2 persons had been realized in the conventional person type (number [of fingers], movement excursion, size, etc. are ordinaries) robot hand, it was very small, and also in what was realized, the mechanism became heavy greatly and the latter example of realization was deficient in it to practicality and ******. It is difficult especially in a robot hand to make drive mechanisms, such as a motor and an example of the gear, build in compactly, and This sake, The number of fingers, the movement excursion, the size, etc. formed the drive mechanism which consists of a motor or reduction gears in the exterior of the hand in about the same conventional human-being type robot hand as human being, and the technique of transmitting power to a fingertip by a wire mechanism has been taken. In this technique, the big occupation space for drive mechanism is needed, the weight of the whole mechanism increases, and there is a problem that decline in the elongation of a wire, the movement accuracy by friction, or efficiency is not avoided further.
[0004]then, the movement mechanism and motor for an abduction [this invention persons] function -- a palm, while storing compactly into a portion, As a result of examining the method of building in very compactly the movement mechanism and motor for an expansion-and-contraction function of each finger for every finger so that it may not interfere with the mechanism, it succeeded in development of the new person type robot hand. The person-himself/herself type robot hand can realize most movements in which the abduction between one flexibility each and latter 4 finger has a total of eight flexibility of 1 flexibility in expansion and contraction of 3 flexibility and other four fingers, and thumb movement can realize people. Even if compared with human being, a complete aircraft style, a motor, and wiring were built in into 185 small mm in overall length and size with a thickness of 19 mm of a finger, and full weight of 500g or less was realized. That is, the specifications top also realized remarkable improved efficiency as compared with the conventional thing.
[0005]

[Means for Solving the Problem]Five finger mechanisms in which a solving means which this invention adopted is equivalent to five fingers of human being, Movement of a first digit which is provided with a palm equivalent to a palm of human being who supports the five finger mechanisms, and is equivalent to the thumb 3 flexibility, Other the 2nd - expansion and contraction of four fingers of the fifth finger are the person type robot hands constituting so that abduction between one flexibility each and latter 4 finger may have a total of eight flexibility of 1 flexibility. A finger mechanism of said second digit - the fifth finger is provided with Section, trifles, a midpiece, basipod, and a metacarpus paragraph, 4 [a total of] sequentially from a fingertip, respectively, and in three terminal areas of each internode. Have the joint of 1 flexibility for bending and stretching a finger, and a motor for a joint drive which performs bending and stretching exercises of a finger is built in basipod, A deceleration mechanism for considering torque of this motor as rotational movement of the joint is built in joint between basipod and a midpiece, Furthermore, it has an interlock for transmitting rotational movement of the joint to joint between a metacarpus paragraph on the same finger mechanism, and basipod, and joint between a midpiece and trifles, It is a person type robot hand characterized by making it pass a distribution cable for a motor for a joint drive, a sensor, etc. which intersect perpendicularly, furthermore arrange an axis of joint between a palm, an axis of a joint axis of a metacarpus internode, a metacarpus paragraph, and basipod, establish space in the intersection part, and are built in a finger mechanism. It has the joint for abduction for realizing opening operation of a finger among four fingers of said second digit - the fifth finger in a terminal area between a metacarpus paragraph of a second digit, a fourth finger, and the fifth finger, and a palm, It is a person type robot hand characterized by having fixed a metacarpus paragraph of the third finger to a palm, being interlocked with a circumference of joint for abduction between palms via a link mechanism, and making it rotate a metacarpus paragraph of the 2nd, 4, and 5 finger further. A circular gear centering on joint for abduction between a metacarpus paragraph and a palm is fixed to a metacarpus paragraph of said fourth finger, It is a person type robot hand building a motor for driving which gears with the circular gear in a palm, and performing abduction operation of the 2nd, 4, and 5 finger via said link mechanism with rocking of a metacarpus paragraph further. An interlock for transmitting rotational movement of joint for expansion and contraction between said basipod and a midpiece to joint between a metacarpus paragraph on the same finger mechanism, and basipod, and joint between a midpiece and trifles, It is a person type robot hand considering it as a wire pulley mechanism in which interlock and joint between a wire pulley mechanism in which interlock and joint between joint between basipod and a midpiece, a metacarpus paragraph, and basipod is rotated, joint between basipod and a midpiece, a midpiece, and trifles is rotated. A wire wound around two pulleys which said wire pulley mechanism is arranged at both the sides of a finger mechanism, the side of a corresponding paragraph is engraved with the belt pulley, it is formed, and correspond is a person type robot hand, wherein between both belt pulleys is rolled by shape of eight. In order that said first digit may be provided with trifles, a midpiece, basipod, and a metacarpus paragraph and may realize 2 flexibility in a root of a first digit sequentially from a fingertip, It has the 1st and 2nd joint provided with drive mechanism respectively independent of a terminal area of a palm and a metacarpus paragraph, and a terminal area of a metacarpus paragraph and basipod, Furthermore, said 1st joint, and its motor for driving and reduction gears are built in a part by the side of common [of a hand of a palm], Furthermore, a motor for driving and reduction gears of said 2nd joint are built in a metacarpus paragraph, Although said two joint does not intersect perpendicularly, it constitutes both angle of torsion as 90 degrees, Arrange a motor which performs bending and stretching exercises of a finger to basipod of a first digit, and a deceleration mechanism for making torque of this motor into torque of the joint is built in joint between basipod and a midpiece, It is a person type robot hand having an interlocking wire mechanism for transmitting rotational movement of joint between basipod and a midpiece to joint between a midpiece and trifles furthermore. Said first digit is a person type robot hand

orientations of a paragraph and it can fix at a suitable torsion angle. Reduction gears which have arranged said motor for a joint drive so that it may become an axis of basipod and parallel which built it in, and were built in joint between basipod and a midpiece, It is a person type robot hand constituting from a crown gear and a planetary gear reduction which make an axis and a center of joint the same, engaging a pinion and a crown gear which were further attached to the axis of rotation of a motor, and transmitting torque of a motor to said reduction gears.

[0006]

[Embodiment of the Invention]Hereafter, the composition of the person type robot hand as an embodiment concerning this invention is explained with reference to drawings. Drawing 1 is a figure showing the overview of a person type robot hand, and arrangement of the all the 19 pieces rotation joint which (**) provides (b) in the side view of the robot hand, provides it in a top view, and provides drawing 2 in the expansion and contraction part of a person type robot hand and the figure showing a name, and drawing 3 are the perspective views and exploded views of a second digit. The person type robot hand shown in said drawing 1 has a first digit – the fifth finger, On each finger of a robot hand, as shown in drawing 2, to a first digit The joint $J_{1, 0}$–$J_{1, 3}$, To a second digit, to the joint $J_{2, 0}$–$J_{2, 3}$, and the third finger The joint $J_{3, 1}$–$J_{3, 3}$, Joint $J_{5, 0}$–$J_{5, \text{and } 3}$ is arranged to the joint $J_{4, 0}$–$J_{4, 3}$, and the fifth finger to a fourth finger, and each finger has composition in which bending and stretching exercises (it mentions later for details) or abduction (it mentions later for details) is possible by these joint parts. Since the joint part of the metacarpus paragraph of the third finger does not need to rotate a longitudinal direction, as shown in drawing 2, the joint $J_{3 \text{ for abduction and } 0}$ are omitted.

[0007][The finger mechanism of the 2–5th fingers] Before explaining the bending and stretching exercises of a finger, and abduction movement, the finger mechanism of the 2–5th fingers for realizing it is explained. Since a first digit has a greatly different structure from other four fingers and it exercises independently of the abduction mechanism of this robot hand, explanation of the structure is mentioned later.

[0008][Paragraph composition of a second digit – the fifth finger] A second digit – the fifth finger are constituted by four paragraphs, respectively, and have composition which can be bent and stretched by each joint part. Drawing 3 is a perspective view of a second digit, and its decomposition part, and as shown in this figure, the finger is provided with the trifles 1, the midpiece 2, the basipod 3, and metacarpus Section 4 sequentially from the fingertip. Although the shape of each metacarpus Section 4 differs a little in a second digit – the fifth finger, since it is not a difference which must change especially explanation a lot, a second digit is henceforth taken up to representation, the mechanism is explained, and explanation of the portion which overlaps about the paragraph mechanism of other third fingers – the fifth finger is omitted.

[0009]In a second digit, metacarpus Section 4 is a paragraph which mediates the palm 5 which is a base of the whole hand the trifles 1 side. Therefore, the joint $J_{2 \text{ and } 1}$ (joint for expansion and contraction) which have 1 flexibility for the joint $J_{2 \text{ and } 0}$ (abduction joint) which have 1 flexibility for abduction functional realization of a finger, and expansion–and–contraction functional realization of a finger intersect perpendicularly, and comprise an inside of metacarpus Section 4. Metacarpus Section 4 has composition which can attain an abduction function focusing on the joint $J_{2 \text{ and } 0}$ to the palm 5, and the basipod 3 can rock to a sliding direction (grip operation) in drawing 3 by the joint $J_{2 \text{ for expansion and contraction, and } 1}$ by these two joint $J_{2, 0}$ and $J_{2, \text{and } 1}$. It is very important to constitute the portion of this metacarpus paragraph compactly, and to obtain a big rotation excursion. Then, neither a motor nor reduction gears are put on this portion other than an axis–of–rotation carrier, but slight power for rotational movement of each joint is made to transmit from the motor arranged at the distant place (it mentions later for details). The joint J[illegible] and the

joint J_2 which connects the midpiece 2 and the basipod 3, and 2 are also the same rotational movement as said joint J_2 and 1. It is constituted as joint for expansion and contraction of the finger which permits [drawing 3 Nakagami down movement (grip operation), i.e., the bending and stretching exercises of a finger,].

[0010][Joint drive mechanism] When the drive mechanism of a knuckle is explained with reference to drawing 4, as for drawing 4 (b), the perspective view of drive mechanism and (**) of the side view of a second digit and (**) are the sectional views of a drive and a deceleration mechanism. The encoder built-in micro motor is built in the basipod 3 for the expansion-and-contraction mechanism of a finger, and the reduction gears are compactly built in said joint J_2 which connects the midpiece 2 and the basipod 3 as shown in figure (**), and 2. The transmission mechanism (wire pulley mechanism mentioned later) by the joint J_2 and the interlocking wire mechanism in which the rotational motion power of 2 is transmitted to the joint J_2 of order, 1, J_2, and 3 is established.

[0011]Since a building envelope can take the basipod 3 and the joint J_2, and comparatively large 2 portion, respectively, it has composition suitable for built-in of the micro motor 13 or the reduction gears 12 for a joint drive. The reduction gears 12 for a joint drive are constituted as three-step reduction gears which consist of planetary gear mechanisms so that it may mention later. The housing space 11 for building a sensor, electronic autoparts, etc. in the portion of a fingertip is formed. It is considered as the composition which the joint J_2, 0, J_2, and 1 can let pass directly to a center of rotation mostly so that movement of a finger mechanism may not be checked, as the distribution cable 14 which comes out from the rear of the micro motor 13 is shown in (b). In order to obtain sufficient output, small and lightweight high-output DC coreless motor is used for all the micro motors 13 used by this robot hand. Position control, speed control, and a torque control are possible for them for building in an encoder and not using an additional sensor in particular.

[0012]Since motor rotation frequency is high in comparison, reduction gears with sufficiently large small size and a moderating ratio are built into a joint part. The three-step reduction gears which consist of a planetary gear mechanism which can expect a big moderating ratio and big transmission power with the small number of gears as reduction gears are adopted. As shown in drawing 9 (**), the planetary gear reduction is being used for a three-step deceleration mechanism as crown reduction gears and 2 or 3rd step reduction gears as a 1st step deceleration mechanism. The axis of rotation of the crown gear which constitutes the 1st step of deceleration mechanism is supporting the 2nd step sun gear, The 3rd step of sun gear formed in the axis of the career provided in the 2nd step epicyclic gear and the 2nd more step of epicyclic gear which mesh with this sun gear, Reduction gears were constituted by the 3rd step of epicyclic gear and the internal gear still more common to said 2 or 3rd step epicyclic gear which mesh with this sun gear, and the pinion provided in the output shaft of the micro motor stored in basipod has geared on said crown gear. The internal gear is formed in the midpiece. The axis of the 2 or 3rd step sun gear which the center of rotation of a crown gear has on the joint J_2 which connects a midpiece and basipod, and the articulated axis of 2 and the same axle, and constitutes said deceleration mechanism on this axis is arranged. And three-step reduction gears are compactly stored in the joint by making common the axis of said reduction gears, and the axis of the joint of the joint J_2 and 2.

[0013]A micro motor is stored so that the axis may become parallel to the longitudinal direction of the basipod 3, and it obtains the rotational motion power of the direction of an articulated axis via a crown gear. In order to obtain a big moderating ratio also in this transmitting power stage, the path of a crown gear is enlarged as much as possible. Generally by a planetary gear mechanism, an output element serves as either of the careers of an internal gear or an epicyclic

gear. Here, in order to give an output to the center of an dactylopodite so that the bias of the load produced in the bearing of the both ends of an articulated axis may become as small as possible, let the internal gear located in central slippage of an articulated axis be an output element.

[0014]It continues and the joint J_2 obtained by said mechanism and the mechanism in which the rotational motion power of 2 is transmitted to the joint J_2 of order, 1, $J_{2, \text{and } 3}$ are explained. An interlocking wire mechanism is used as a transmission mechanism. In drawing 5, (b) is a perspective view of a second digit and (**) is an exploded view of the finger. In this transmission mechanism that consists of wire pulleys, the wire W1 which interlocks the joint $J_{2, 1}$, $J_{2, \text{and } 2}$, and the wire W2 which interlocks the joint $J_{2, 2}$, $J_{2, \text{and } 3}$ are arranged by both side of a finger mechanism, respectively.

[0015]The pulley for each wires is formed by engraving the side of an dactylopodite. The two pulleys 21 and 22 and middle pulleys 23 are needed as an object for the wires W1. On a metacarpus paragraph, the belt pulley 22 is carved, and is been [the belt pulley / it] crowded and formed, on the midpiece, the belt pulley 21 is carved, and is been [the belt pulley / it] crowded and formed, and the wire W1 is covered over the shape of 8 via the middle pulley 23 at the belt pulleys 21 and 22 at both. As shown in drawing 5 (**), the end of the wire W1 is pinched on a metacarpus paragraph, and is fixed with a stop board, and the wire W1 fits into the hole in which the ball attached on the wire was formed on the midpiece, and is fixed to a midpiece. Among the two pulleys 24 and 25 for wire W2, basipod is engraved with the belt pulley 25, it is been [the belt pulley / it] crowded and formed in it, and trifles are engraved with the belt pulley 24, it is been [the belt pulley / it] crowded and formed in them, and the wire W2 is covered over the shape of 8 at each belt pulley. The wire W2 is inserted in in the hole which the ball provided on the wire formed in said belt pulley 25, and as shown in drawing 6, it lets the end of a wire pass in the hole formed in trifles, and it is being further fixed with the stop board on both sides of the point.

[0016]It has a small light weight very much, the interlocking wire mechanism which consists of a wire pulley constituted in this appearance has a big rotation excursion, and since there is no backlash which is seen by the train of gears, it turns into a highly precise and efficient transmission mechanism. The bending and stretching exercises by such an expansion-and-contraction mechanism are shown in drawing 6. It will be in the state where a base will bend if a micro motor is specifically driven, this motion is interlocked with further, a midpiece and trifles bend via an interlocking wire mechanism, and it is shown in drawing 6. The situation of the person type robot hand in the state where the second digit was bent is shown in drawing 7 and drawing 8.

[0017]Although the bending and stretching exercises of the above-mentioned second digit are as common as a fourth finger and the fifth finger, about the third finger, the composition of a metacarpus paragraph is a little different. Since it is not necessary to give the abduction function mentioned later to the third finger, the metacarpus paragraph of the third finger is being fixed to the palm so that it may mention later.

[0018]It continues and the abduction mechanism of a person type robot hand is explained. It is the figure made to shift to the state where it opened from the state where drawing 9 closed (b) and (**) closed the hand, and is an explanatory view of a link mechanism in which drawing 10 constitutes the perspective view of an abduction mechanism, and drawing 11 constitutes an abduction mechanism. Abduction operation is operation changed into the state where the finger opened as shown in drawing 9 (**) by interlocking and rotating the metacarpus paragraph of the 2nd, 4, and 5 finger among 4 of the 2-5th fingers fingers. In order to realize this abduction mechanism, the metacarpus paragraph of the third finger is being fixed to the palm which is a base of the whole hand. In order to acquire strong torque efficiently, as shown in drawing 11, the biggest possible circular gear 31 of a pitch circle radius is fixed to the metacarpus paragraph of a fourth finger. Said circular gear 31 is constituted rockable focusing on the joint P5 formed in

the root of the fourth finger, and a fourth finger performs opening operation by rocking movement of this circular gear 31. Said circular gear 31 engages with the pinion 32 provided on the axis of the crown gear 33 arranged at the end of a palm. Crown gear 33 It has geared with the gear provided in the output shaft of the abduction motor 34 arranged to the [palm]. Operation which the crown gear 33 will rotate if the abduction motor 34 rotates, the pinion 32 rotates further, is rocked focusing on the joint $J_{4 \text{ and } 0}$ which the circular gear 31 has arranged at the root of a fourth finger, and a fourth finger opens by this composition is performed.

[0019]The interlocking link mechanism in which rotational movement of the metacarpus paragraph of a fourth finger is transmitted to the metacarpus paragraph of the second digit of both sides and the fifth finger with an interlocking link mechanism is explained. An interlocking link mechanism consists of four paragraphs of L1-L4, as shown in drawing 11. The link L1 connects one end at the metacarpus paragraph and the joint P1 of a second digit, and connects the other end at the link L2 and the joint P2. The link L2 connects one end at the link L1 and the joint P2, connects the other end at the link L3 and the joint P4, and connects the center of the link L2 with a palm at the joint P3.

[0020]The link L3 connects one end at the link L2 and the joint P4, and connects the other end at the metacarpus paragraph and the joint P5 of a fourth finger. The link L4 is a fourth finger about an end. [Metacarpus paragraph] It connects at the joint P6 and the other end is connected at the metacarpus paragraph and the joint P7 of the fifth finger. If the circular gear 31 drives by the abduction motor 34, movement which the metacarpus paragraph of a fourth finger opens by the motion will be carried out, It is transmitted to the metacarpus paragraph of a second digit so that the movement may become reverse [a hand of cut] via the links L1-L3, and it is transmitted to the metacarpus paragraph of a second digit and the fifth finger so that an angle of rotation may be expanded via the link L4. In this way, an abduction function can be attained.

[0021]In the above-mentioned composition, in order to obtain the movement space of a metacarpus paragraph, and the built-in space of wiring or electronic autoparts inside a palm, it is important to allot a circular gear and its movement space to the outer casing nearness by the side of the back of a hand, and to store an interlocking link in the space between a metacarpus paragraph and the outer casing by the side of a palm thinly. The arrangement relationship of an abduction motor, a crown gear, and the circular gear 31 is shown in drawing 12. At the time of a design, these arrangement can be changed freely. The perspective view of the interlocking link for a drive of an abduction mechanism is shown in drawing 13.

[0022]Finally the finger mechanism of a first digit is explained. The figure with which drawing 14 explains the maximum introvert state of a first digit, the figure with which drawing 15 explains the paragraph composition of a first digit, and drawing 16 are the figures explaining the joint drive mechanism of a first digit. As shown in drawing 15, four paragraphs constitute a first digit. It is considered as trifles, a midpiece, basipod, and a metacarpus paragraph from a fingertip at order. In order to realize the motor function carried out to oppose a first digit to other fingers, the origin of human being's thumb builds the respectively independent drive mechanism of the two joint $J_{1, 0}$, $J_{1, \text{ and } 1}$ into the root of a first digit the same with having 2 flexibility. That is, the metacarpus paragraph of the first digit is provided with the 1st joint J_1 provided with drive mechanism respectively independent of the terminal area of a metacarpus paragraph and a palm, and the terminal area of a metacarpus paragraph and basipod, 0, the 2nd joint $J_{1, \text{ and } 1}$ in order to realize 2 flexibility.

[0023]the palm of a palm -- a near part -- swelling (human being's thumb is the same with existing in a root) -- it provides, and as shown in drawing 16, the 1st joint $J_{1, 0}$, and its motor for driving and reduction gears are built in. In a first digit, it is considered as the structure which fixes the internal gear of these reduction gears to the motor side in order to shorten a metacarpus paragraph, and fixes the axis of an epicyclic gear to the side of the metacarpus

paragraph which is an output side. The 2nd joint $J_{1,}$ and the motor for driving and reduction gears of 1 are built in a metacarpus paragraph. For this reason, although the two joint $J_{1, 0}$, $J_{1,}$ and 1 do not intersect perpendicularly, they make both angle of torsion 90 degrees. The basic constitution of the reduction gears of this portion presupposes that it is the same as that of the thing for the expansion-and-contraction function in the 2-4th fingers mentioned above.

[0024]The joint $J_{1,}$ and the motor for driving and reduction gears of 2 are built in basipod. Rotational movement of the joint J_1 and 2 is transmitted to the joint J_1 and 3 with an interlocking wire mechanism. These interlocking wire mechanisms presuppose that it is the same as that of the thing for the expansion-and-contraction mechanism in the 2-4th fingers mentioned above. In order to adjust the direction of the inside of the first digit in the state of carrying out a first digit for making it facing other four fingers, the rotating part of the shaft orientations of a paragraph is provided in the center of basipod, and it enables it to fix the joint $J_{1, 2}$, $J_{1,}$ and 3 by suitable angle of torsion.

[0025]As mentioned above, in the embodiment concerning above-mentioned this invention. the movement mechanism and motor for an abduction function -- a palm -- while storing compactly into the portion, the movement mechanism and motor for an expansion-and-contraction function of each finger were built in very compactly for every finger so that it might not interfere with the mechanism -- a sake -- a small and new person type robot hand -- it was able to constitute . Especially the person-himself/herself type robot hand can realize movement of most fingers that people can realize because thumb movement drives the motor which the abduction between one flexibility each and latter 4 finger has a total of eight flexibility of 1 flexibility, and expansion and contraction of 3 flexibility and other four fingers have arranged in a finger.

[0026]Although the embodiment of this invention has been described above, the movement mechanism and motor for an abduction function -- a palm -- while storing compactly into a portion, it is not limited to the movement mechanism for the expansion-and-contraction function of each finger, and the mechanism of the above-mentioned explanation as a method of building in a motor very compactly for every finger so that it may not interfere with the mechanism. This invention can be carried out in any of other forms, without deviating from the pneuma or main features. Therefore, at all points, the above-mentioned embodiment is only mere illustration, and must not be interpreted restrictively.

[0027]

[Effect of the Invention]As for the person type robot hand concerning this invention, thumb movement can realize most movements in which the abduction between one flexibility each and latter 4 finger has a total of eight flexibility of 1 flexibility, and expansion and contraction of 3 flexibility and other four fingers can realize people. Even if it compares with human being, the effect which was excellent in ** -- it can be considered as a small robot hand -- can be done so.

[Translation done.]

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報**（Ａ）　(11)特許出願公開番号
特開2003－117873
（P2003－117873A）
(43)公開日　平成15年４月23日(2003.4.23)

(51)Int.Cl.⁷	識別記号	ＦＩ	ﾃｰﾏｺｰﾄﾞ(参考)
Ｂ２５Ｊ　15/08		Ｂ２５Ｊ　15/08	Ｋ　３Ｃ００７

審査請求　未請求　請求項の数９　ＯＬ　（全 11 頁）

(21)出願番号　特願2001－316828(P2001－316828)

(22)出願日　平成13年10月15日(2001.10.15)

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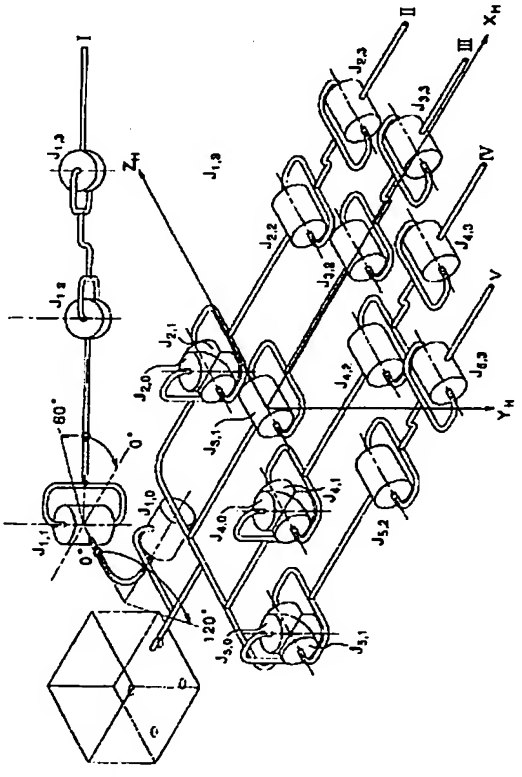
最終頁に続く

(54)【発明の名称】　人型ロボットハンド

(57)【要約】
【課題】各指の屈伸機能、親指を他の指と向かい合わせにする運動機能および指同士の開閉（アブダクション；ａｂｄｕｃｔｉｏｎ）機能を備えた人型ロボットハンドを提供する。
【解決手段】人間の５指に相当する５本の指機構Ｉ、ＩＩ、ＩＩＩ、ＩＶ、Ｖと、その５本の指機構を支持する人間の掌に相当する掌部を備え、親指に相当する第１指Ｉの運動が３自由度、他の第２～第５指の４指の屈伸が１自由度、および後者４指間のアブダクションが１自由度の計８自由度を有するように構成したことを特徴とする人型ロボットハンド。



【特許請求の範囲】

【請求項１】人間の５指に相当する５本の指機構と、その５本の指機構を支持する人間の掌に相当する掌部を備え、親指に相当する第１指の運動が３自由度、他の第２～第５指の４指の屈伸が各１自由度、および後者４指間のアブダクションが１自由度の計８自由度を有するように構成したことを特徴とする人型ロボットハンド。

【請求項２】前記第２指～第５指の指機構は、指先から順にそれぞれ末節、中節、基節、中手節の計４節を備え、各節間の接続部３箇所には、指の屈伸を行うための１自由度のジョイントを有し、基節には指の屈伸運動を行うジョイント駆動用モータを内蔵し、基節と中節間のジョイントには該モータの回転力をそのジョイントの回転運動とするための減速機構を内蔵し、さらにそのジョイントの回転運動を、同一指機構上の中手節と基節間のジョイントおよび中節と末節間のジョイントに伝達するための連動機構を備え、さらに掌部と中手節間のジョイント軸の軸と中手節と基節間のジョイントの軸を直交して配置し、その交点部に空間を設けて指機構に内蔵するジョイント駆動用モータやセンサ等のための配線ケーブルを通過するようにしたことを特徴とする請求項１に記載の人型ロボットハンド。

【請求項３】前記第２指～第５指の４指のうち、第２指、第４指、第５指の中手節と掌部間の接続部には指の開き動作を実現するためのアブダクション用ジョイントを有し、また第３指の中手節は掌部に固定され、さらに第２、４、５指の中手節をリンク機構を介して掌部との間のアブダクション用ジョイント周りに連動して回転するようにしたことを特徴とする請求項２に記載の人型ロボットハンド。

【請求項４】前記第４指の中手節に、中手節と掌部間のアブダクション用ジョイントを中心とする円弧歯車を固定し、掌部にその円弧歯車に噛み合う駆動用モータを内蔵し、さらに中手節の揺動により前記リンク機構を介して第２、４、５指のアブダクション動作を行うようにしたことを特徴とする請求項３に記載の人型ロボットハンド。

【請求項５】前記基節と中節間の屈伸用ジョイントの回転運動を、同一指機構上の中手節と基節間のジョイントおよび中節と末節間のジョイントに伝達するための連動機構は、基節と中節間のジョイントと中手節と基節間のジョイントを連動して回転させるワイヤ・プーリ機構と、基節と中節間のジョイントと中節と末節間のジョイントを連動して回転させるワイヤ・プーリ機構としたことを特徴とする請求項２～請求項４のいずれかに記載の人型ロボットハンド。

【請求項６】前記ワイヤ・プーリ機構は、指機構の両脇に配置され、そのプーリは対応する節の側面に彫られて形成され、対応する二つのプーリに巻回するワイヤは両プーリ間を８の字型に巻かれていることを特徴とする請求項５に記載の人型ロボットハンド。

【請求項７】前記第１指は、指先から順に、末節、中節、基節、中手節を備え、第１指の根元における２自由度を実現するために、掌部と中手節との接続部および中手節と基節との接続部にそれぞれ独立の駆動機構を備えた第１、第２ジョイントを備え、さらに掌部の手の平側の一部に前記第１ジョイントおよびその駆動用モータと減速機を内蔵し、さらに中手節に前記第２ジョイントの駆動用モータと減速機を内蔵し、前記二つのジョイントは直交しないが両者のねじれ角を９０度として構成し、また第１指の基節には指の屈伸運動を行うモータを配置し、基節と中節間のジョイントには該モータの回転力をそのジョイントの回転力とするための減速機構を内蔵し、さらに基節と中節間のジョイントの回転運動を、中節と末節間のジョイントに伝達するための連動ワイヤ機構を備えたことを特徴とする請求項１～請求項６のいずれかに記載の人型ロボットハンド。

【請求項８】前記第１指は、その基部の中央部に節の軸方向の回転部分を備え、適切なねじれ角度で固定できるように構成されていることを特徴とする請求項７に記載の人型ロボットハンド。

【請求項９】前記ジョイント駆動用モータは、それを内蔵した基節の軸と平行になる様に配置し、また基節と中節間のジョイントに内蔵した減速機は、ジョイントの軸と中心を同一とするクラウンギヤおよび遊星歯車減速機で構成し、さらにモータの回転軸に取り付けたピニオンとクラウンギヤを噛み合わせ、モータの回転力を前記減速機に伝動することを特徴とする請求項２～請求項８のいずれかに記載の人型ロボットハンド。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、各指の屈伸機能、親指を他の指と向かい合わせにする運動機能および指同士の開閉（アブダクション；ａｂｄｕｃｔｉｏｎ）機能を備えた人型ロボットハンドに関するものである。

【０００２】

【従来の技術】ペン持ちや手話などのように、細かくかつ広範囲な指先の運動を必要とする人型ロボットハンドにおいては、各指の屈伸機能、親指を他の指と向かい合わせにする運動機能が必要であるだけでなく、指同士の開閉（アブダクション；ａｂｄｕｃｔｉｏｎ）機能が必要である。

【０００３】

【発明が解決しようとする課題】従来の人型（指の数、運動可動域、大きさ等が人間並み）ロボットハンドでは、前２者は実現されてきたが、後者の実現例は極めて少なく、また実現したものにおいても機構が大きく重くなり実用性・汎用性に乏しいものばかりであった。特にロボットハンド内にモータや歯車例などの駆動機構をコンパクトに内蔵させることが困難であり、このため、指

の数、運動可動域、大きさ等が人間並みの従来人間型ロボットハンドでは、モータや減速機からなる駆動機構を手の外部に設け、ワイヤ機構で動力を指先まで伝達する手法が取られてきた。この手法では、駆動機構のための大きな占有空間を必要とし、機構全体の重量がかさみ、さらにワイヤの伸びや摩擦による運動精度や効率の低下が避けられないという問題がある。

【０００４】そこで、本発明者らは、アブダクション機能用の運動機構とモータを掌部分の中へコンパクトに収納するとともに、その機構と干渉しないように、各指の屈伸機能用の運動機構とモータを各指毎に極めてコンパクトに内蔵する方法の検討を行った結果、新規な人型ロボットハンドの開発に成功した。本人型ロボットハンドは、親指運動が３自由度、他の４指の屈伸が各１自由度、および後者４指間のアブダクションが１自由度の計８自由度を有し、人が実現できる大抵の運動を実現可能である。また、人間と比較しても小形である、全長１８５ｍｍ、指の太さ１９ｍｍの寸法内へ全機構とモータおよび配線を内蔵し、全重量５００ｇ以下を実現した。すなわち、諸元上も従来のものに比較して顕著なる性能向上を実現した。

【０００５】

【課題を解決するための手段】本発明が採用した解決手段は、人間の５指に相当する５本の指機構と、その５本の指機構を支持する人間の掌に相当する掌部を備え、親指に相当する第１指の運動が３自由度、他の第２～第５指の４指の屈伸が各１自由度、および後者４指間のアブダクションが１自由度の計８自由度を有するように構成したことを特徴とする人型ロボットハンドである。また、前記第２指～第５指の指機構は、指先から順にそれぞれ末節、中節、基節、中手節の計４節を備え、各節間の接続部３箇所には、指の屈伸を行うための１自由度のジョイントを有し、基節には指の屈伸運動を行うジョイント駆動用モータを内蔵し、基節と中節間のジョイントには該モータの回転力をそのジョイントの回転運動とするための減速機構を内蔵し、さらにそのジョイントの回転運動を、同一指機構上の中手節と基節間のジョイントおよび中節と末節間のジョイントに伝達するための連動機構を備え、さらに掌部と中手節間のジョイント軸の軸と中手節と基節間のジョイントの軸を直交して配置し、その交点部に空間を設けて指機構に内蔵するジョイント駆動用モータやセンサ等のための配線ケーブルを通過するようにしたことを特徴とする人型ロボットハンドである。また、前記第２指～第５指の４指のうち、第２指、第４指、第５指の中手節と掌部間の接続部には指の開き動作を実現するためのアブダクション用ジョイントを有し、また第３指の中手節は掌部に固定され、さらに第２、４、５指の中手節をリンク機構を介して掌部との間のアブダクション用ジョイント周りに連動して回転するようにしたことを特徴とする人型ロボットハンドである。前記第４指の中手節に、中手節と掌部間のアブダクション用ジョイントを中心とする円弧歯車を固定し、掌部にその円弧歯車に噛み合う駆動用モータを内蔵し、さらに中手節の揺動により前記リンク機構を介して第２、４、５指のアブダクション動作を行うようにしたことを特徴とする人型ロボットハンドである。また、前記基節と中節間の屈伸用ジョイントの回転運動を、同一指機構上の中手節と基節間のジョイントおよび中節と末節間のジョイントに伝達するための連動機構は、基節と中節間のジョイントと中手節と基節間のジョイントを連動して回転させるワイヤ・プーリ機構と、基節と中節間のジョイントと中節と末節間のジョイントを連動して回転させるワイヤ・プーリ機構としたことを特徴とする人型ロボットハンドである。また、前記ワイヤ・プーリ機構は、指機構の両脇に配置され、そのプーリは対応する節の側面に彫られて形成され、対応する二つのプーリに巻回するワイヤは両プーリ間を８の字型に巻かれていることを特徴とする人型ロボットハンドである。また、前記第１指は、指先から順に、末節、中節、基節、中手節を備え、第１指の根元における２自由度を実現するために、掌部と中手節との接続部および中手節と基節との接続部にそれぞれ独立の駆動機構を備えた第１、第２ジョイントを備え、さらに掌部の手の平側の一部に前記第１ジョイントおよびその駆動用モータと減速機を内蔵し、さらに中手節に前記第２ジョイントの駆動用モータと減速機を内蔵し、前記二つのジョイントは直交しないが両者のねじれ角を９０度として構成し、また第１指の基節には指の屈伸運動を行うモータを配置し、基節と中節間のジョイントには該モータの回転力をそのジョイントの回転力とするための減速機構を内蔵し、さらに基節と中節間のジョイントの回転運動を、中節と末節間のジョイントに伝達するための連動ワイヤ機構を備えたことを特徴とする人型ロボットハンドである。また、前記第１指は、その基部の中央部に節の軸方向の回転部分を備え、適切なねじれ角度で固定できるように構成されていることを特徴とする人型ロボットハンドである。また、前記ジョイント駆動用モータは、それを内蔵した基節の軸と平行になる様に配置し、また基節と中節間のジョイントに内蔵した減速機は、ジョイントの軸と中心を同一とするクラウンギヤおよび遊星歯車減速機で構成し、さらにモータの回転軸に取り付けたピニオンとクラウンギヤを噛み合わせ、モータの回転力を前記減速機に伝動することを特徴とする人型ロボットハンドである。

【０００６】

【実施の形態】以下、本発明に係る実施形態としての人型ロボットハンドの構成を図面を参照して説明する。図１は人型ロボットハンドの全体像を示す図であり、（イ）は同ロボットハンドの側面図、（ロ）は平面図、図２は人型ロボットハンドの屈伸部に設ける全１９個の回転ジョイントの配置、および呼び名を示す図、図３は

第２指の斜視図および分解図である。前記図１に示す人型ロボットハンドは、第１指～第５指を有しており、ロボットハンドの各指には図２に示すように第１指に対してジョイント$J_{1,0}$～$J_{1,3}$、第２指に対してジョイント$J_{2,0}$～$J_{2,3}$、第３指に対してジョイント$J_{3,1}$～$J_{3,3}$、第４指に対してジョイント$J_{4,0}$～$J_{4,3}$、第５指に対してジョイント$J_{5,0}$～$J_{5,3}$が配置され、これらのジョイント部で各指が屈伸運動（詳細は後述する）あるいはアブダクション（詳細は後述する）可能な構成となっている。なお、第３指の中手節のジョイント部は、左右方向に回転させる必要がないため、図２に示すようにアブダクション用のジョイント$J_{3,0}$は省略されている。

【０００７】〔第２～５指の指機構〕指の屈伸運動およびアブダクション運動を説明する前に、それを実現するための第２～５指の指機構について説明する。なお、第１指は他の４指と大きく異なる構造を持ち、本ロボットハンドのアブダクション機構と独立に運動するので、その構造の説明は後述する。

【０００８】〔第２指～第５指の節構成〕第２指～第５指は、それぞれ四つの節により構成されており、各関節部で屈伸できる構成となっている。図３は第２指の斜視図およびその分解部であり、この図に示すように、指は指先から順に、末節１、中節２、基節３、中手節４を備えている。なお、第２指～第５指においてそれぞれの中手節４の形状が若干異なるが、特に説明を大きく変えなければならない差異ではないので、以後は第２指を代表に取り上げてその機構を説明し、他の第３指～第５指の節機構については重複する部分の説明は省略する。

【０００９】第２指において、中手節４が末節１側とハンド全体の基部である掌部５を仲介する節である。そのため、中手節４の内部で、指のアブダクション機能実現のための１自由度を有するジョイント$J_{2,0}$（アブダクションジョイント）と、指の屈伸機能実現のための１自由度を有するジョイント$J_{2,1}$（屈伸用ジョイント）が直交して構成されている。この二つのジョイント$J_{2,0}$および$J_{2,1}$により、中手節４は掌部５に対してジョイント$J_{2,0}$を中心にアブダクション機能を達成でき、また基節３が屈伸用ジョイント$J_{2,1}$により図３中で上下方向（握り動作）に揺動できる構成となっている。この中手節の部分をコンパクトに構成し、かつ大きな回転可動域を得ることが極めて重要である。そこで、この部分には回転軸受以外にモータや減速機を置かず、それぞれのジョイントの回転運動用動力は、少し離れたところに配置したモータから伝達することにする（詳細は後述する）。また、末節１と中節２とを接続するジョイント$J_{2,3}$、および、中節２と基節３とを接続するジョイント$J_{2,2}$も前記ジョイント$J_{2,1}$と同じ回転運動〔図３中上下方向の運動即ち指の屈伸運動（握り動作）〕を許容する指の屈伸用ジョイントとして構成されている。

【００１０】〔関節駆動機構〕指関節の駆動機構を図４を参照して説明すると、図４（イ）は第２指の側面図、（ロ）は駆動機構の斜視図、（ハ）は駆動・減速機構の断面図である。指の屈伸機構のためにエンコーダ内蔵型の超小型モータが基節３に内蔵されており、その減速機が図（ハ）に示すように中節２と基節３とを接続する前記ジョイント$J_{2,2}$にコンパクトに内蔵されている。また、ジョイント$J_{2,2}$の回転動力を前後のジョイント$J_{2,1}$，$J_{2,3}$に伝達する連動ワイヤ機構による伝達機構（後述するワイヤ・プーリ機構）が設けられている。

【００１１】基節３およびジョイント$J_{2,2}$部分はそれぞれ内部空間が比較的大きく取れるので、超小型モータ１３や関節駆動用減速機１２の内蔵に適した構成としてある。関節駆動用減速機１２は後述するように遊星歯車機構からなる３段減速機として構成されている。また、指先の部分にセンサーや電装品等を内蔵するための格納空間１１が形成されている。さらに、超小型モータ１３の後部から出る配線ケーブル１４が（イ）に示すように指機構の運動を阻害しないように、それをジョイント$J_{2,0}$，$J_{2,1}$のほぼ回転中心に直接的に通せる構成とされている。十分な出力を得る為に、本ロボットハンドで使用する全ての超小型モータ１３は、小形・軽量で高出力のＤＣコアレスモータを採用する。また、それらはエンコーダを内蔵し、特に付加的なセンサを用いずに位置制御、速度制御、トルク制御が可能となっている。

【００１２】モータ回転数が比較的に高いため、十分に小形かつ減速比の大きな減速機が関節部に組み込まれる。減速機として、少ない歯車数で大きな減速比および大きな伝達動力が期待できる遊星歯車機構からなる３段減速機を採用する。３段減速機構は、図９（ハ）に示すように１段目減速機構としてクラウン減速機、２、３段目減速機として遊星歯車減速機を使用している。１段目の減速機構を構成するクラウンギヤの回転軸は２段目太陽歯車を支持しており、この太陽歯車に噛み合う２段目遊星歯車、さらに２段目の遊星歯車に設けたキャリアの軸に設けた３段目の太陽歯車、この太陽歯車に噛み合う３段目の遊星歯車、さらに前記２、３段目遊星歯車に共通な内歯車によって減速機が構成され、基節内に収納された超小型モータの出力軸に設けたピニオンが前記クラウンギヤに噛み合っている。また内歯車は中節内に設けられている。クラウンギヤの回転中心は中節と基節とを接続するジョイント$J_{2,2}$の関節軸と同軸上にあり、またこの軸上には前記減速機構を構成する２、３段目太陽歯車の軸が配置されている。そして前記減速機の軸とジョイント$J_{2,2}$の関節の軸を共通とすることにより、関節内に３段減速機がコンパクトに収められている。

【００１３】超小型モータは基節３の長手方向に対してその軸が平行となる様に収納され、クラウンギアを介して関節軸方向の回転動力を得る。また、この動力伝達段階でも大きな減速比を得るために、クラウンギアの径を

出来る限り大きくする。一般的に遊星歯車機構では出力要素が内歯車か遊星歯車のキャリアのいずれかとなる。ここでは、関節軸の両端の軸受に生ずる負荷の偏りが出来る限り小さくなるように、指節の中央へ出力を与えるために、関節軸の中央寄りに位置する内歯車を出力要素とする。

【００１４】つづいて、前記機構によって得られたジョイント$J_{2,2}$の回転動力を前後のジョイント$J_{2,1}$，$J_{2,3}$に伝達する機構について説明する。伝達機構として連動ワイヤ機構を用いる。図５において、（イ）は第２指の斜視図、（ロ）は同指の分解図である。ワイヤ・プーリからなるこの伝達機構では、ジョイント$J_{2,1}$，$J_{2,2}$を連動するワイヤＷ１と、ジョイント$J_{2,2}$，$J_{2,3}$を連動するワイヤＷ２をそれぞれ指機構の両脇に配置する。

【００１５】各ワイヤ用のプーリは、指節の側面に彫り込むことにより形成する。ワイヤＷ１用として二つのプーリ２１，２２と中間プーリ２３が必要となる。プーリ２２は中手節上に彫り込まれて形成され、プーリ２１は中節上に彫り込まれて形成されており、プーリ２１、２２には中間プーリ２３を介してワイヤＷ１が両者に８の字型にかけられる。ワイヤＷ１の端部は図５（ロ）に示すように中手節上に挟み留め板によって固定され、またワイヤＷ１はワイヤ上に取り付けた玉を中節上に形成した穴に嵌合して中節に固定される。また、ワイヤＷ２用の二つのプーリ２４，２５のうち、プーリ２５は基節に彫り込まれて形成され、またプーリ２４は末節に彫り込まれて形成され、それぞれのプーリにはワイヤＷ２が８の字型にかけられる。ワイヤＷ２はワイヤ上に設けた玉が前記プーリ２５に形成した穴へはめ込まれ、ワイヤの端部は図６に示すように末節に形成した穴に通し、さらにその先を挟み留め板によって固定されている。

【００１６】この様に構成するワイヤ・プーリからなる連動ワイヤ機構は、極めて小形軽量で、大きな回転可動域を有し、歯車列にみられる様なガタが無いので高精度かつ高効率の伝達機構となる。このような屈伸機構による屈伸運動を図６に示す。具体的には超小型モータを駆動すると基部が曲がり、さらにこの動きに連動して連動ワイヤ機構を介して中節、末節が曲がり図６に示すような状態となる。図７、図８に第２指を折り曲げた状態の人型ロボットハンドの様子を示す。

【００１７】上記第２指の屈伸運動は第４指、第５指と共通であるが、第３指については中手節の構成が若干相違している。第３指には後述するアブダクション機能を与える必要がないため、第３指の中手節は後述するように掌部に固定されている。

【００１８】つづいて、人型ロボットハンドのアブダクション機構を説明する。図９は（イ）、（ロ）は手を閉じた状態から開いた状態へと移行させた図であり、図１０はアブダクション機構の斜視図、図１１はアブダクション機構を構成するリンク機構の説明図である。アブダクション動作は、第２～５指の４指の内、第２、４、５指の中手節を連動して回転させることにより図９（ロ）に示すように指が開いた状態とする動作である。このアブダクション機構を実現するために、第３指の中手節は、ハンド全体の基部である掌部に固定されている。また、強い回転力を効率よく得るために、図１１に示すように第４指の中手節にピッチ円半径の出来る限り大きな円弧歯車３１を固定する。前記円弧歯車３１は第４指の根元に設けたジョイントＰ５を中心に揺動可能に構成されており、この円弧歯車３１の揺動運動により第４指が開き動作を行う。また、前記円弧歯車３１は掌部の端に配置したクラウンギヤ３３の軸上に設けたピニオン３２とかみ合わせる。クラウンギヤ３３は〔掌部〕に配置したアブダクションモータ３４の出力軸に設けたギヤと噛み合っている。この構成により、アブダクションモータ３４が回転するとクラウンギヤ３３が回転し、さらにピニオン３２が回転して、円弧歯車３１が第４指の根元に配置したジョイント$J_{4,0}$を中心に揺動し第４指が開く動作を行う。

【００１９】第４指の中手節の回転運動を、連動リンク機構により、両側の第２指および第５指の中手節に伝達する連動リンク機構の説明をする。連動リンク機構は図１１に示すようにＬ１～Ｌ４の四つの節から構成する。リンクＬ１は、一端を第２指の中手節とジョイントＰ１で連結し、他端をリンクＬ２とジョイントＰ２で連結する。リンクＬ２は、一端をリンクＬ１とジョイントＰ２で連結し、他端をリンクＬ３とジョイントＰ４で連結し、リンクＬ２の中央を掌部とジョイントＰ３で連結する。

【００２０】リンクＬ３は、一端をリンクＬ２とジョイントＰ４で連結し、他端を第４指の中手節とジョイントＰ５で連結する。リンクＬ４は、一端を第４指の〔中手節〕とジョイントＰ６で連結し、他端を第５指の中手節とジョイントＰ７で連結する。アブダクションモータ３４によって円弧歯車３１が駆動されると、その動きにより第４指の中手節が開く運動をし、その運動がリンクＬ１～Ｌ３を介して回転方向が逆となる様に第２指の中手節に伝達され、リンクＬ４を介して回転角を拡大する様に第２指および第５指の中手節に伝達される。こうしてアブダクション機能を達成することができる。

【００２１】また、上記構成において、掌部の内部に中手節の運動空間、および配線や電装品の内蔵空間を得るために、円弧歯車およびその運動空間を手の甲側の外装板間近に配し、また連動リンクを中手節と手のひら側の外装板との間の空間に薄く収めることが重要である。図１２にアブダクションモータ、クラウンギヤ、円弧歯車３１の配置関係を示す。なおこれらの配置は設計時において自由に変更することが可能である。図１３にアブダクション機構の駆動用連動リンクの斜視図を示す。

【００２２】最後に第１指の指機構について説明する。図１４は第１指の最大内転状態を説明する図、図１５は第１指の節構成を説明する図、図１６は第１指の関節駆動機構を説明する図である。第１指は図１５に示すように四つの節により構成する。指先から順に末節，中節，基節，中手節とする。第１指を他の指と向かい合わせにする運動機能を実現するために人間の親指の根本が２自由度を有することと同様に，第１指の根元に二つのジョイント$J_{1,0}$、$J_{1,1}$のそれぞれ独立の駆動機構を組み込む。即ち、第１指の中手節は、２自由度を実現するために中手節と掌部との接続部および中手節と基節との接続部にそれぞれ独立の駆動機構を備えた第１ジョイント$J_{1,0}$、第２ジョイント$J_{1,1}$を備えている。

【００２３】掌部の手の平側の一部にふくらみ（人間の親指の根元に存在するのと同様）を設け、図１６に示すように第１ジョイント$J_{1,0}$およびその駆動用モータと減速機を内蔵する。第１指では中手節を短くするためにこの減速機の内歯車をモータ側へ固定し、遊星歯車の軸を出力側である中手節の側面へ固定する構造とする。中手節に第２ジョイント$J_{1,1}$の駆動用モータと減速機を内蔵する。このために二つのジョイント$J_{1,0}$、$J_{1,1}$は直交しないが両者のねじれ角を９０度とする。この部分の減速機の基本構成は前述した第２～４指における屈伸機能のためのものと同一とする。

【００２４】基節にジョイント$J_{1,2}$の駆動用モータと減速機を内蔵する。ジョイント$J_{1,2}$の回転運動をジョイント$J_{1,3}$に連動ワイヤ機構により伝達する。これらの連動ワイヤ機構は前述した第２～４指における屈伸機構のためのものと同一とする。さらに、第１指を他の４指と向かい合わせにする状態での第１指の腹の方向を調整するために基節の中央に節の軸方向の回転部分を設け、ジョイント$J_{1,2}$、$J_{1,3}$を適切なねじれ角で固定できるようにする。

【００２５】以上のように、上記本発明に係る実施形態では、アブダクション機能用の運動機構とモータを掌部分の中へコンパクトに収納するとともに、その機構と干渉しないように、各指の屈伸機能用の運動機構とモータを各指毎に極めてコンパクトに内蔵したため、小型で新規な人型ロボットハンドを構成することができた。特に本人型ロボットハンドは、親指運動が３自由度、他の４指の屈伸が各１自由度、および後者４指間のアブダクションが１自由度の計８自由度を有しており、また指内に配置したモータを駆動することで、人が実現できる大抵の指の運動を実現することができる。

【００２６】以上本発明の実施形態について説明してきたが、アブダクション機能用の運動機構とモータを掌部分の中へコンパクトに収納するとともに、その機構と干渉しないように、各指の屈伸機能用の運動機構とモータを各指毎に極めてコンパクトに内蔵する方法として、上記説明の機構に限定されることはない。また本発明はその精神または主要な特徴から逸脱することなく、他のいかなる形でも実施できる。そのため、前述の実施形態はあらゆる点で単なる例示にすぎず限定的に解釈してはならない。

【００２７】

【発明の効果】本発明に係る人型ロボットハンドは、親指運動が３自由度、他の４指の屈伸が各１自由度、および後者４指間のアブダクションが１自由度の計８自由度を有し、人が実現できる大抵の運動を実現することができる。また、人間と比較しても小形なロボットハンドとすることができる、等々の優れた効果を奏することができる。

【図面の簡単な説明】

【図１】ロボットハンドの全体像を示す。

【図２】ロボットハンドに設ける全１９個の回転ジョイントの配置、および呼び名を示す。

【図３】第２指の節構成を示す。

【図４】第２指の関節駆動機構を示す。

【図５】第２指の連動ワイヤ機構を示す。

【図６】第２指の連動ワイヤ機構によって指を曲げた状態の説明図である。

【図７】第２指の屈伸機能により、第２指が極めて大きく内側へ曲がる（内転する）ことを示す。

【図８】第２指が３つのジョイント$J_{2,1}$、$J_{2,2}$、$J_{2,3}$を軸として回転することを示す。なお、他の４指も同様の屈伸機能を有する。

【図９】アブダクション機能として、第２、４、５指がそれぞれジョイント$J_{2,0}$、$J_{4,0}$、$J_{5,0}$軸として回転することを示す。

【図１０】アブダクション駆動機構を示す。

【図１１】アブダクション駆動用連動リンク機構の透視図を示す。

【図１２】アブダクション駆動機構の横断面を示す。

【図１３】アブダクション駆動用連動リンクを示す。

【図１４】第１指を他の指と向かい合わせにする運動機能として、第１指がジョイント$J_{1,0}$を軸として大きく内転することを示す。

【図１５】第１指の節構成を示す。

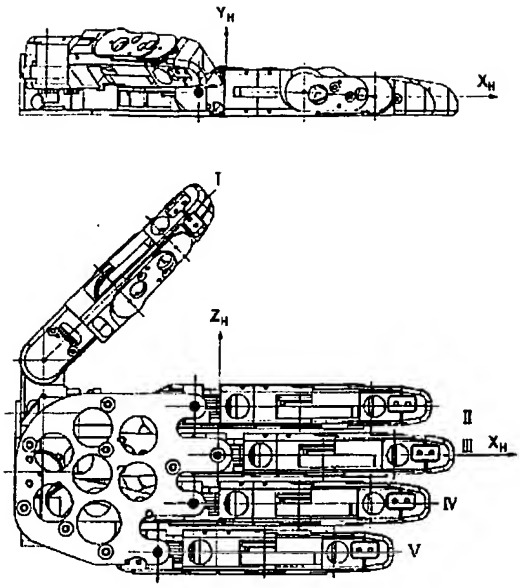
【図１６】第１指の関節駆動機構を示す。

【符号の説明】

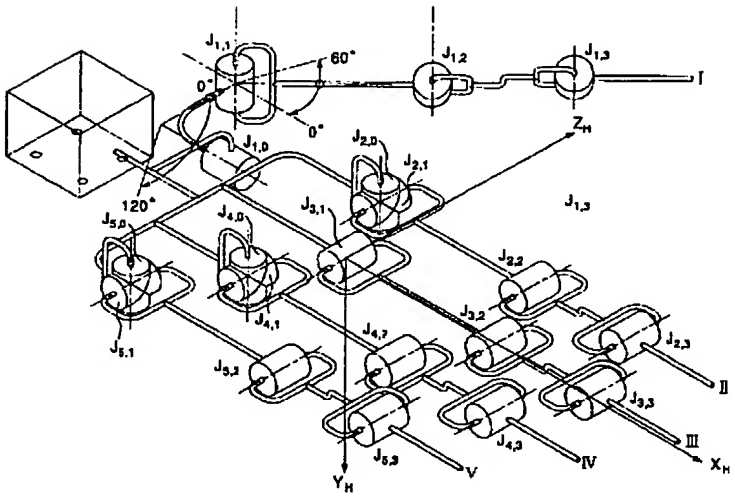
１	末節
２	中節
３	基節
４	中手節
５	掌部
１１	センサーや電装品等を内蔵するための格納空間
１２	減速機
１３	超小型モータ
２１、２２	プーリ

23	中間プーリ	32	ピニオン
24、25	プーリ	33	クラウンギヤ
31	円弧歯車	34	アブダクション駆動用モータ

【図1】

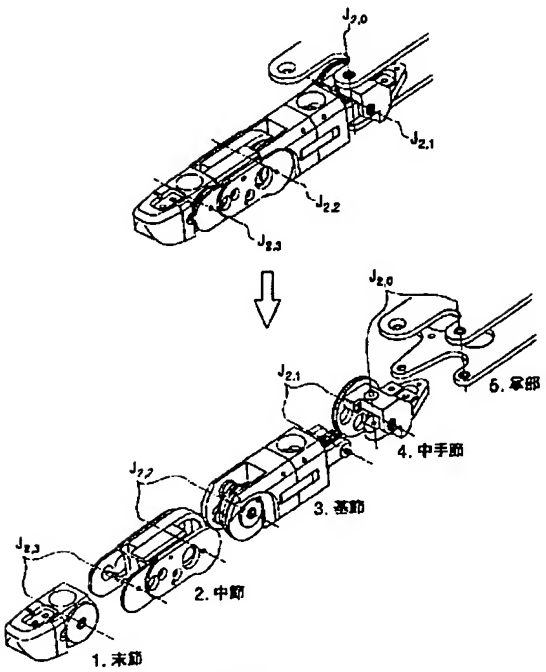


【図2】

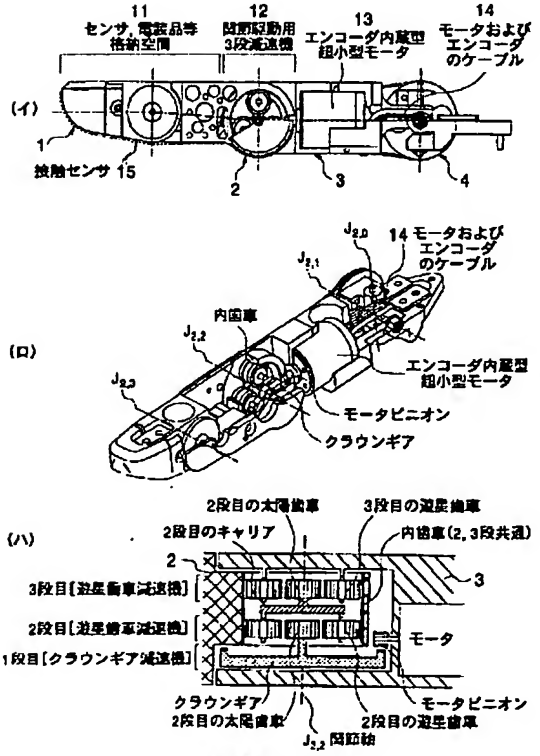


【図4】

【図3】

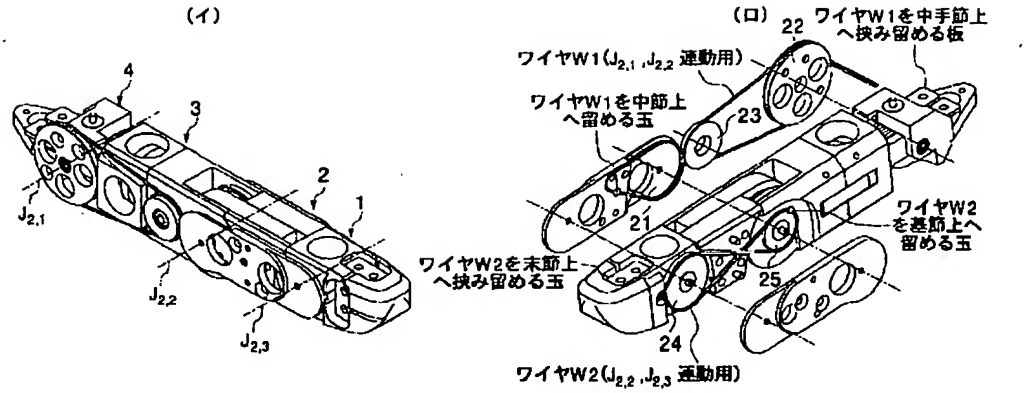


第2指の節構成

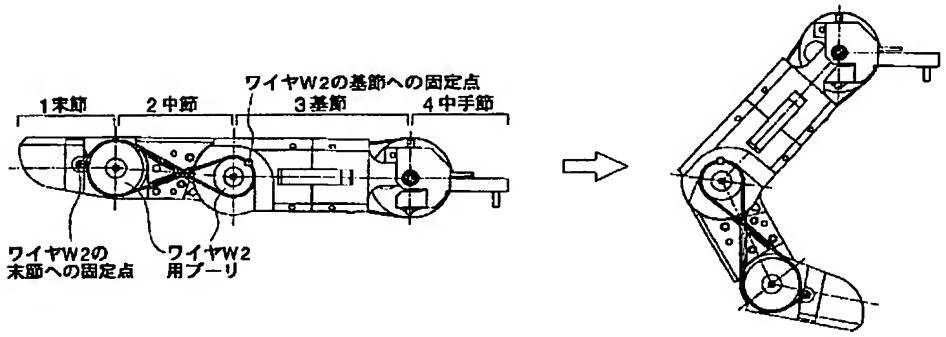


第2指の関節駆動機構

【図5】

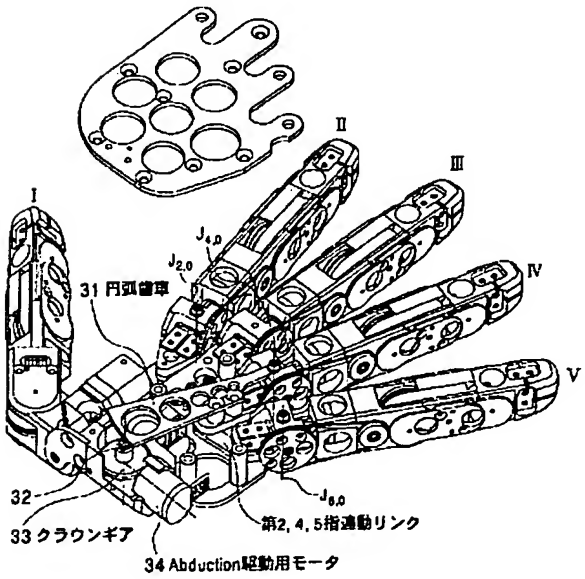


【図6】



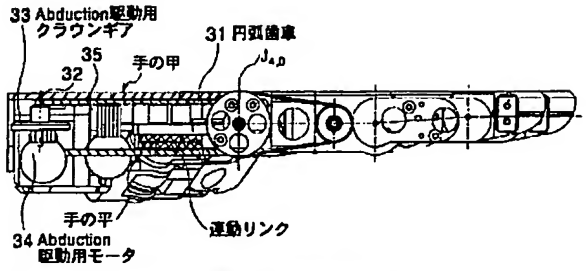
第2指の連動ワイヤ機構

【図10】



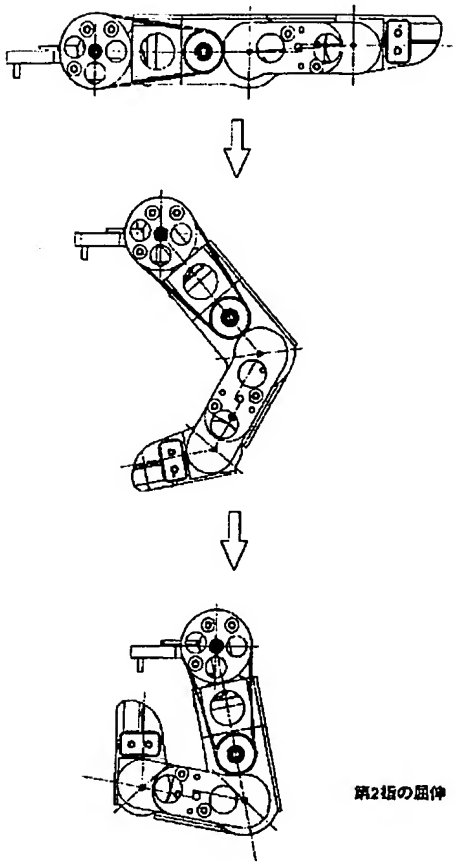
Abduction駆動機構

【図12】



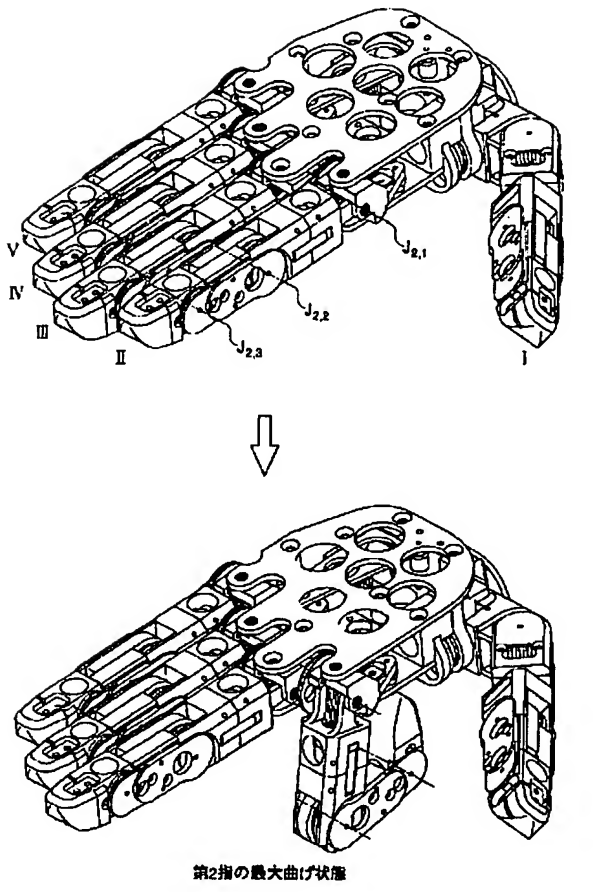
Abduction駆動機構の断面

【図7】



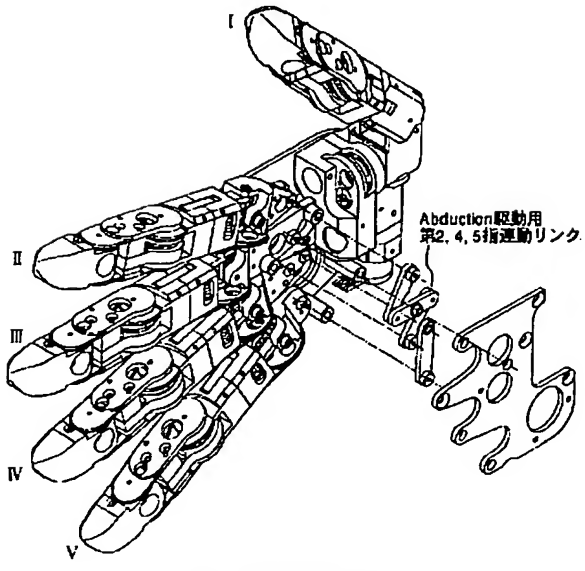
第2指の屈伸

【図8】



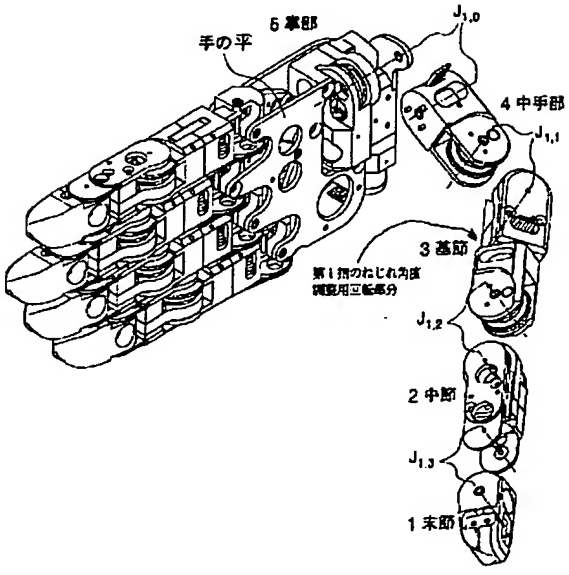
第2指の最大曲げ状態

【図13】



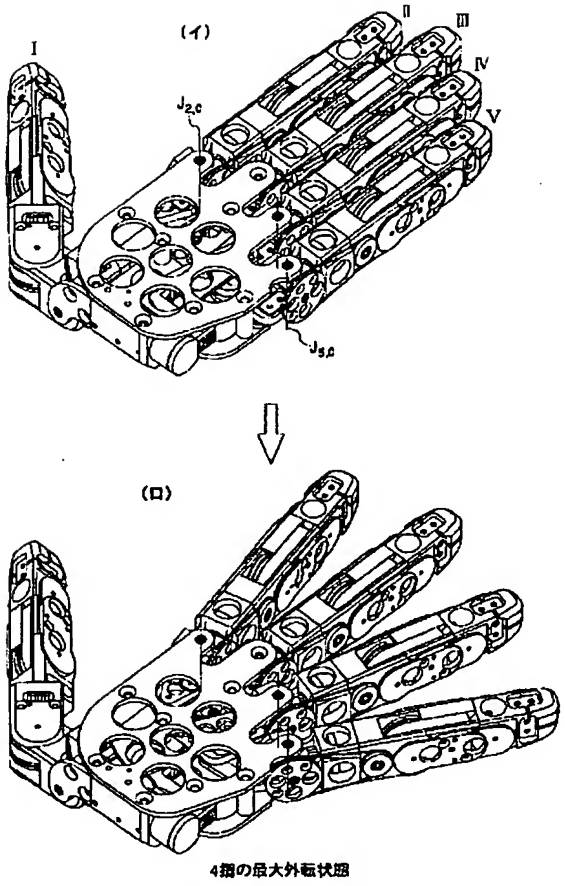
Abduction駆動用連動リンク

【図15】



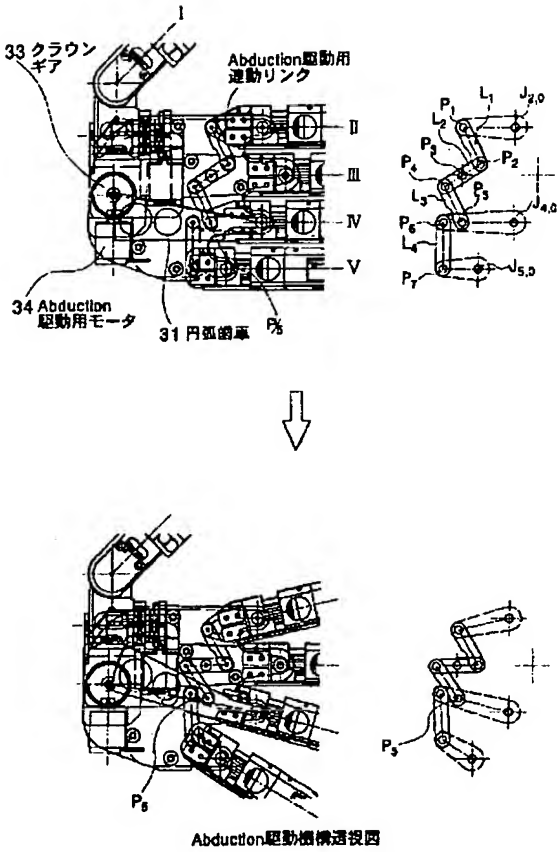
第1指の関節構成

【図9】



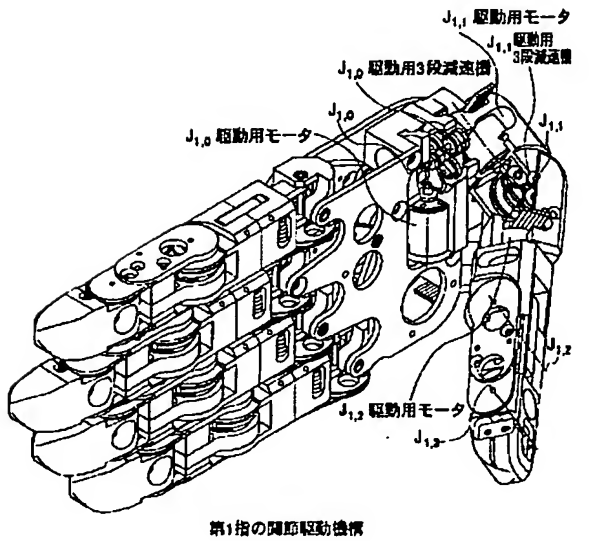
4指の最大外転状態

【図11】



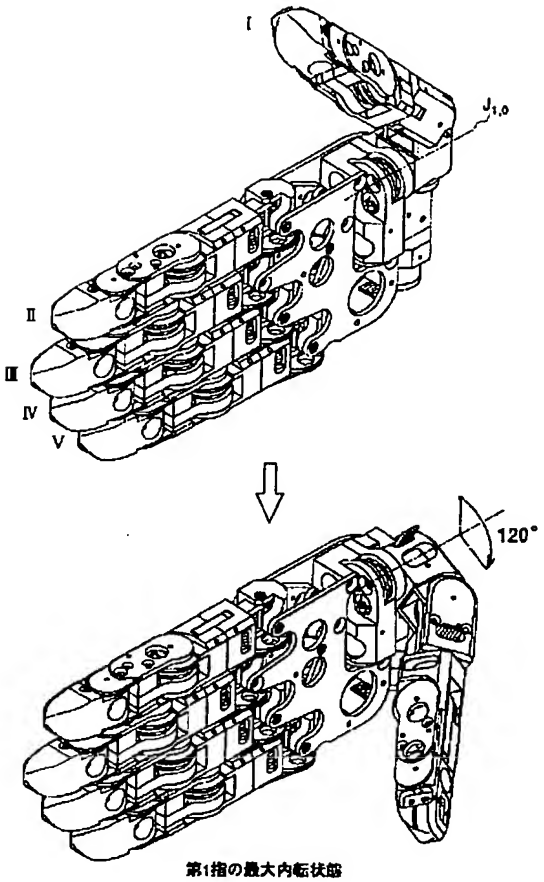
Abduction駆動機構透視図

【図16】



第1指の関節駆動機構

【図14】



第1指の最大内転状態

フロントページの続き

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Fターム(参考)　3C007 ES09 ET03 EU06 EU07 EU11 EW00 HS27 KV01 KX08

EUROPEAN PATENT OFFICE

Patent Abstracts of Japan

PUBLICATION NUMBER : 2001347482
PUBLICATION DATE : 18-12-01

APPLICATION DATE : 27-02-01
APPLICATION NUMBER : 2001052732

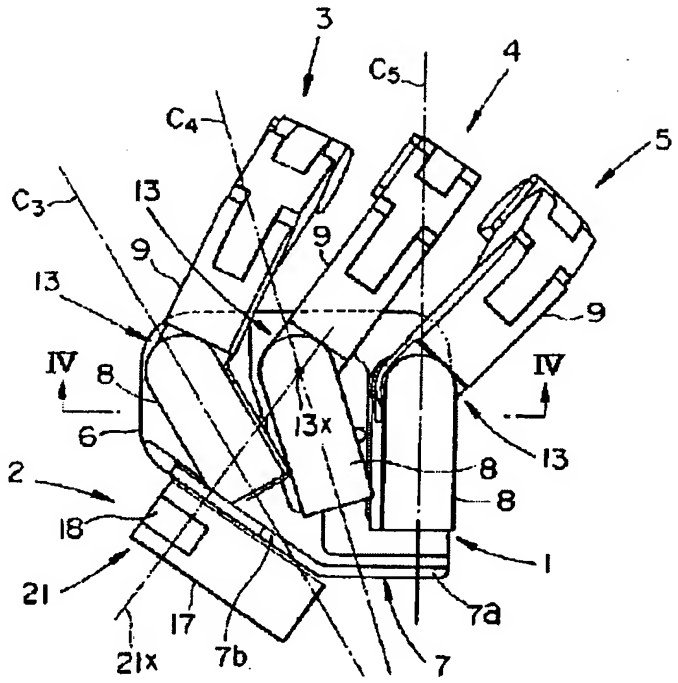
APPLICANT : HONDA MOTOR CO LTD;

INVENTOR : KISHIMOTO KAZUHIRO;

INT.CL. : B25J 15/08

TITLE : MULTI-FINGER HAND DEVICE

FIG. 3



ABSTRACT : PROBLEM TO BE SOLVED: To provide a multi-finger hand device capable of easily and efficiently performing the grasping operation of an object.

SOLUTION: In this multi-finger hand device having finger mechanisms 2-5, the rotating axis 21x of the joint 21 closest to the palm part 1 of the finger mechanism 2 corresponding to the thumb is substantially orthogonal to the rotating axis 13x of the joint 13 closest to the palm part 1 of the finger mechanism 4. The rotating axis 13x of the joint 13 closest to the palm part 1 of each of the finger mechanism 3-5 is slightly inclined and extended in the direction substantially orthogonal to the palm body plate 6 of the palm part 1. The link mechanism 8 closest to the palm part 1 of each of the finger mechanisms 3-5 is fixed to the palm part 1 with the respective central line C3, C4, or C5 being inclined.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the hyperdactyly hand equipment which has two or more finger mechanisms.
[0002]
[Description of the Prior Art]As for the hyperdactyly hand equipment which has the same structure as people's hand, two or more finger mechanisms are installed from a palm part, and via two or more joints, each of that finger mechanism connects two or more link mechanisms one by one, and is constituted. And the actuator which operates each joint (for example, the flection action of each joint is made to perform) is formed in each link mechanism (see JP,8-126984,A etc.).
[0003]However, conventional hyperdactyly hand equipment could not be said to be that the operation direction and arrangement configuration of a joint of each of that finger mechanism are what can not necessarily perform properly gripping operation of the object of all sorts by hyperdactyly hand equipment, but to improve this was desired.
[0004]
[Problem(s) to be Solved by the Invention]This invention is made in view of this background, and is a thing.
the purpose is to provide the hyperdactyly hand equipment which makes it possible to perform easily gripping operation of the object boiled and twisted efficiently.

[0005]
[Means for Solving the Problem]It has two or more finger mechanisms installed from a palm part, each finger mechanism is related with hyperdactyly hand equipment possessing two or more link mechanisms connected one by one via two or more joints from said palm part side, and hyperdactyly hand equipment of this invention has the 1st - the 3rd mode as the fundamental mode.
[0006]In this 1st mode, a finger mechanism (here, henceforth a thumb mechanism) equivalent to the thumb of said two or more finger mechanisms most A shaft center of a joint (here, henceforth the 1st joint) by the side of a palm part, at least one finger mechanism (here, henceforth a specific finger mechanism) in other finger mechanisms other than a finger mechanism equivalent to this thumb -- a shaft center of a joint by the side of a palm part crosses most -- as (it crosses desirable almost right-angled -- as) -- both the finger mechanism concerned -- a joint by the side of a palm part is arranged most.
[0007]According to this composition, it becomes more possible than the 1st joint of a thumb mechanism by performing both the 1st joint of said thumb mechanism, the 1st joint of said specific finger mechanism, or one rotating operation to make a portion by the side of a tip meet on the same flat surface rather than a portion by the side of a tip and the 1st joint of a specific

finger mechanism. Therefore, an object between these thumb mechanisms and specific finger mechanisms can be grasped easily.

[0008]A joint of others other than each 1st joint of said thumb mechanism and a specific finger mechanism in the 1st mode of this invention, For example, although it may be the composition of having the flexibility of a multiple spindle, respectively, when it is what has especially the flexibility of one axis, it is preferred for the shaft center that it is what intersects perpendicularly with a shaft center of said 1st joint (when rotating operation of a circumference of one shaft center is possible).

[0009]Each 1st joint of other finger mechanisms of all the other than a finger mechanism (thumb mechanism) which is equivalent to the thumb of said two or more finger mechanisms in the 2nd mode of this invention that is a joint by the side of a palm part most, Arrange the shaft center in parallel crosswise [of this palm part / abbreviated] towards a direction which abbreviated-intersects perpendicularly with a hand flat surface of said palm part, and it is provided, being concerned -- others -- a link mechanism (here, henceforth the 1st link mechanism) which connects with said each 1st joint of all the finger mechanisms, and is most located in the palm part side is being fixed to said palm part so that a center line of each of the cross direction may incline mutually and may spread radiately toward the tip side of each finger mechanism.

[0010]According to this 2nd mode, other finger mechanisms of all the other than a thumb mechanism, i.e., a finger mechanism arranged in parallel crosswise [of said palm part / abbreviated]. Since the axis of rotation of each of the 1st joint of said is turned in the direction which abbreviated-intersects perpendicularly with a hand flat surface of a palm part, the portion by the side of a tip can carry out abbreviated ****** rotating operation to a hand flat surface of a palm part in a part of this 1st joint rather than the 1st joint of those finger mechanisms. And at this time the 1st link mechanism of finger mechanisms other than a thumb mechanism, Since it is being fixed to said palm part so that a center line of each of the cross direction may incline mutually and may spread radiately toward the tip side of each finger mechanism, it becomes possible to cross each finger mechanism to a wide rotating range, avoiding interference with a ******** mechanism, and to rotate it around a shaft center of the 1st joint. That is, it becomes possible to make it rotate to a circumference of a shaft center of the 1st joint over a comparatively wide range, without rotating each finger mechanism and ******** mechanisms other than a thumb mechanism to a circumference of a shaft center of each 1st joint more than needed. As a result, a finger mechanism becomes possible [taking easily a posture suitable for grasping of an object of all sorts].

[0011]In the 2nd mode of this invention, when it is what has the flexibility of one axis, it is preferred for especially each joint other than the 1st joint of each finger mechanism other than a thumb mechanism that the shaft center is what intersects perpendicularly with a shaft center of the 1st joint. About a thumb mechanism, when each of that joint is what has the flexibility of one axis, A shaft center of the 1st joint of other finger mechanisms and a shaft center of the 1st joint by the side of a palm part abbreviated-cross at right angles most, and, as for a shaft center of each of other joint of this thumb mechanism, it is still more preferred that it is what intersects perpendicularly with a shaft center of the 1st joint of this thumb mechanism.

[0012]In the 3rd mode of this invention, each of other finger mechanisms of all the other than a finger mechanism (thumb mechanism) equivalent to the thumb of said two or more finger mechanisms most a joint (the 1st joint) by the side of a palm part, It is stood in a row and provided crosswise [of this palm part / abbreviated], and it is provided so that the shaft center may incline mutually towards abbreviated-intersecting perpendicularly with a hand flat surface of said palm part and may spread radiately toward the shell side of this palm part.

[0013]Since according to the 3rd mode of this this invention it is provided so that a shaft center of the 1st joint by the side of a palm part may incline mutually in the direction of other finger mechanisms other than a thumb mechanism which abbreviated-intersects perpendicularly with a

palm part, When operating a joint by the side of a tip rather than the 1st joint of each of those finger mechanisms and bending a portion by the side of a tip to the hand flat-surface side rather than this 1st joint, it will become easy to concentrate a tip part of those finger mechanisms on a part soon. For this reason, grasping of an object using those finger mechanisms becomes easy.

[0014]In the 3rd mode of this invention, like the 2nd mode, when it is what has the flexibility of one axis, it is preferred for especially each joint other than the 1st joint of each finger mechanism other than a thumb mechanism that the shaft center is what intersects perpendicularly with a shaft center of the 1st joint. About a thumb mechanism, when each of that joint is what has the flexibility of one axis, A shaft center of the 1st joint of other finger mechanisms and a shaft center of the 1st joint by the side of a palm part abbreviated-cross at right angles most, and, as for a shaft center of each of other joint of this thumb mechanism, it is still more preferred that it is what intersects perpendicularly with a shaft center of the 1st joint of this thumb mechanism.

[0015]As for the 1st - the 3rd mode of this invention explained above, it is needless to say that it may adopt complexly. In this case, in adopting the 2nd mode as the 1st mode of this invention further. Each 1st joint of other finger mechanisms of all the other than a finger mechanism (thumb mechanism) equivalent to said thumb that is a joint by the side of a palm part most, Arrange the shaft center in parallel crosswise [of this palm part / abbreviated] towards a direction which abbreviated-intersects perpendicularly with a hand flat surface of said palm part, and it is provided, being concerned -- others -- a link mechanism which connects with said each 1st joint of all the finger mechanisms, and is most located in the palm part side is fixed to said palm part so that a center line of each of the cross direction may incline mutually and may spread radiately toward the tip side of each finger mechanism.

[0016]In adopting the 3rd mode as the 1st mode of this invention, Each of other finger mechanisms of all the other than a finger mechanism (thumb mechanism) equivalent to the thumb of said two or more finger mechanisms most a joint (the 1st joint) by the side of a **** part, It is stood in a row and provided crosswise [of this **** part / abbreviated], and it is provided so that the shaft center may incline mutually towards abbreviated-intersecting perpendicularly with a hand flat surface of said palm part and may spread radiately toward the shell side of this palm part.

[0017]In adopting the 3rd mode as the 2nd mode of this invention, Said each 1st joint of other finger mechanisms of all the other than a finger mechanism (thumb mechanism) equivalent to the thumb of said two or more finger mechanisms is provided so that the shaft center may incline mutually towards abbreviated-intersecting perpendicularly with a hand flat surface of said palm part and may spread radiately toward the shell side of this palm part.

[0018]As for other finger mechanisms other than a finger mechanism (thumb mechanism) which is equivalent to the thumb among said two or more finger mechanisms also in the 1st - which 3rd mode in this invention explained above, it is preferred that the at least two finger mechanisms of each other are constituted by the same structure.

[0019]According to this, the finger mechanisms of the same structure can be mutually diverted to some other purpose. For this reason, inventory management of those finger mechanisms becomes easy, and it can respond to exchange treatment of this finger mechanism at the time of breaking down one of the finger mechanisms of those easily.

[0020]In this invention, an actuator to which rotating operation of each joint of each finger mechanism is made to perform is provided for example, in each finger mechanism also in the 1st - which 3rd mode. In this case, when at least two finger mechanisms of each other are especially constituted by the same structure as mentioned above, the finger mechanisms of the same structure can be mutually diverted to some other purpose including this actuator by providing an actuator to which rotating operation of each joint of each finger mechanism is made to perform in each finger mechanism.

[0021]About drive mechanism of a joint of each finger mechanism in this invention. For example, a rotational driving means of an electric motor for [of each finger mechanism] driving a joint between this and a ****** link mechanism most to each link mechanism other than a link mechanism by the side of a tip, etc., It is preferred to have composition which carries a rotation transmission means (a reduction gear etc. are included) to transmit rotation driving force of this rotational driving means to this joint.

[0022]

[Embodiment of the Invention]One embodiment of this invention is described with reference to drawing 1 - drawing 10.

[0023]Drawing 1 and drawing 2 are the perspective views showing the basic structure of the hyperdactyly hand equipment of this embodiment, and they are the perspective view which drawing 1 turned the hand flat surface of hyperdactyly hand equipment up, and was shown, and the perspective view which drawing 2 turned the wrist glove side of hyperdactyly hand equipment up, and was shown. In drawing 1 and drawing 2, each finger mechanisms 2-5 of the expedient top of explanation and hyperdactyly hand equipment simplify and indicate only the important section composition, and are omitting the component of an actuator etc.

[0024]As shown in drawing 1 and drawing 2, the hyperdactyly hand equipment of this embodiment is provided with the following.

Palm part 1.

Two or more finger mechanisms 2-5 installed from this palm part 1.

In this embodiment, the number of the finger mechanisms 2-5 is four, among these the finger mechanism 2 is equivalent to the thumb of people's hand.

[0025]The palm part 1 is formed of a tabular member, and comprises the palm body plate 6 with which the surface turns into the hand flat surface 6a (refer to drawing 1), and the erect plate 7 which stood up to the wrist glove side (rear-face side of the palm body plate 6) with the posture which abbreviated-intersects perpendicularly with this palm body plate 6 from the rear end part of this palm body plate 6. The rear face (field by the side of a wrist glove) of the palm body plate 6 is a surface part to which the finger mechanisms 3-5 of the finger mechanisms 2-5 are attached (refer to drawing 2).

[0026]The erect plate 7 comprises the 1st partial erect plate 7a which extends crosswise [of the palm part 1 / abbreviated], and the 2nd partial erect plate 7b which inclines and extends to this 1st partial erect plate 7a in the end side of this 1st partial erect plate 7a. The portion in which the 1st partial erect plate 7a is attached to the arm (arm object) of the robot which is not illustrated, and the 2nd partial erect plate 7b are portions to which the finger mechanism 2 is attached.

[0027]the finger mechanisms 3-5 are all the same structures among the finger mechanisms 2-5 -- respectively -- the [the 1st -] -- the five link mechanisms 8-12 of five -- the order from the palm part 1 side -- the [the 1st -] -- it has structure connected via the four joints 13-16 of four. Since all are the same structures as mentioned above, the finger mechanisms 3-5 are omitting each link mechanism and the reference mark of each joint about the finger mechanism 4 for convenience in drawing 1 and drawing 2.

[0028]Although a more detailed structure of these finger mechanisms 3-5 is mentioned later, each joint 13-16 of each is a joint which all enables rotational movement of the circumference of 1 axis. And in this embodiment, the shaft center of the 1st joint 13 of palm part 1 slippage lies at right angles to the shaft center (these are mutually parallel) of other three the 2nd - 4th joint 14-16 most.

[0029]Namely, when the finger mechanism 5 is explained with reference to drawing 1, for example, the 1st joint 13 of this finger mechanism 5, Making the 2nd link mechanism 9 pivotable to the 1st link mechanism 8 around the shaft center 13x of a graphic display, the 2nd joint 14 makes the 3rd link mechanism 10 pivotable to the 2nd link mechanism 9 around the shaft center 13x of the 1st joint 13, and the shaft center 14x which intersects perpendicularly. To the 3rd

center 15x parallel to the shaft center 14x of the 2nd joint 14, and the 4th joint 16, The 5th link mechanism 12 is made pivotable to the 4th link mechanism 11 around the shaft center 16x parallel to the shaft center 15x of the 3rd joint 15.

[0030]The rotating operation of such the 1st - the 4th joint 13-16 is completely the same also about the finger mechanisms 3 and 4. And in this embodiment, it is fixed to the reverse part of this palm body plate 6 towards the direction which abbreviated-intersects perpendicularly with the palm body plate 6 of the palm part 1, and each 1st link mechanism 8 of the finger mechanisms 3-5 arranges in parallel the shaft center 13x of the 1st joint 13 crosswise [of this palm body plate 6 / abbreviated] (refer to drawing 2).

[0031]Here, the attachment composition of the palm body plate 6 and each 1st link mechanism 8 of the finger mechanisms 3-5 is further explained with reference to drawing 3 and drawing 4. Drawing 3 is an III view figure (top view seen from the wrist glove side of the palm part 1 in the shaft center 13 x direction of the 1st joint 13 of the finger mechanism 4) of drawing 2, and drawing 4 is an IV-IV line sectional view of drawing 3. In drawing 4, the imaginary line shows the 1st link mechanism 8 of the finger mechanisms 3-5.

[0032]As shown in drawing 3, in this embodiment each 1st link mechanism 8 of the finger mechanisms 3-5, It is fixed to the reverse part of the palm body plate 6, as the center line C3 of the cross direction, C4, and C5 incline mutually and those center lines C3, C4, and C5 spread radiately toward the tip side of the finger mechanisms 3-5. For this reason, when the finger mechanisms 3-5 are lengthened in the direction of the center line C3, C4, and C5, respectively, the finger mechanisms 3-5 will extend radiately from the palm part 1 side.

[0033]The surface part 6x which the palm body plate 6 is formed in this embodiment so that it may be crooked crosswise a little in the hand flat-surface 6a side, as shown in drawing 4, and adheres the 1st link mechanism 8 of the finger mechanism 3 of the reverse part of the palm body plate 6, The surface part 6y which adheres the 1st link mechanism 8 of the finger mechanism 4, and the surface part 6z which adheres the 1st link mechanism 8 of the finger mechanism 5 incline a little mutually. For this reason, where each 1st link mechanism 8 of the finger mechanisms 3-5 is fixed to these surface parts 6x, 6y, and 6z. The shaft center 13x of the 1st joint 13 of each finger mechanisms 3-5 that is a joint by the side of the palm part 1 most also inclines a little mutually, and those shaft centers 13x extend so that it may spread radiately toward the wrist glove side like a graphic display. Angle-of-gradient thetaa [as opposed to / in this case / the shaft center 13x (this extends in the perpendicular direction of drawing 4) of the 1st joint 13 of the finger mechanism 4 at this embodiment] of the shaft center 13x of the 1st joint 13 of the finger mechanism 5, It is almost the same as angle-of-gradient thetab (for example, 5 times) of the shaft center 13x of the 1st joint 13 of the finger mechanism 3 to the shaft center 13x of the 1st joint 13 of the finger mechanism 4, or has a little bigger angle (for example, 5 to 10 degrees) than it.

[0034]referring to drawing 1 and drawing 2 on the other hand -- the finger mechanism 2 -- the [the 1st -] -- the four link mechanisms 17-20 of four -- the order from the palm part 1 side -- the [the 1st -] -- it has structure connected via the three joints 21-23 of three.

[0035]Each joints 21-23 of this finger mechanism 2 like the 1st - the 3rd joint 13-15 of said finger mechanisms 3-5, All are the joints which enable rotational movement of the circumference of 1 axis, and the shaft center of the 1st joint 21 of palm part 1 slippage lies at right angles to the shaft center (these are mutually parallel) of other 2nd and 3rd two joints 22 and 23 most.

[0036]Namely, carry out the drawing 1 reference and the 1st joint 21 of the finger mechanism 2, Making the 2nd link mechanism 18 pivotable to the 1st link mechanism 17 around the shaft center 21x of a graphic display, the 2nd joint 22 makes the 3rd link mechanism 19 pivotable to the 2nd link mechanism 18 around the shaft center 21x of the 1st joint 21, and the shaft center 22x which intersects perpendicularly. The 3rd joint 23 makes the 4th link mechanism 20 pivotable to the 3rd link mechanism 19 around the shaft center 23x parallel to the shaft center

22x of the 2nd joint 22.

[0037]And in this embodiment, the finger mechanism 2 is fixed to the outside-surface part of this 2nd partial erect plate 7b towards the direction (the palm body plate 6 and abbreviation parallel direction) to which the 2nd partial erect plate 7b of the palm part 1 and the 1st link mechanism 17 cross at right angles the shaft center 21x of the 1st joint 21.

[0038]In this case, in this embodiment, as the shaft center 21x of that 1st joint 21 shows said drawing 3, the finger mechanism 2 is the position and the posture which the shaft center 13x and abbreviated right angle of the 1st joint 13 of the finger mechanism 4 of other above-mentioned finger mechanisms 3-5 are crossed, and is being fixed to the 2nd partial erect plate 7b.

[0039]A still more detailed structure of said finger mechanisms 2-5 is explained with reference to drawing 5 - drawing 8.

[0040]Drawing 5 and drawing 6 are the exploded perspective views disassembling and showing the finger mechanism 3 of the finger mechanisms 3-5 which are the same structures in the part of each joints 13-16. In drawing 5, in this case, the lateral portion 3 of the venter of the finger mechanism 3, i.e., a finger mechanism, it is a lateral portion of the same side as the hand flat surface 6a of said palm part 1 -- drawing 1 and drawing 2 -- the lateral portion (henceforth an intrados part) which meets the hand flat surface 6a of the palm part 1 in the state where the finger mechanism 3 was made crooked like is turned in the direction of the arrow A in drawing 5 (above). In drawing 6, the intrados part of the finger mechanism 3 is turned in the direction of the arrow B in the figure (transverse direction). Drawing 7 is in the state which lengthened the finger mechanism 3, and the top view seen from the intrados part side and drawing 8 are the VIII view figures of drawing 7.

[0041]As shown in drawing 5 - drawing 7, the 1st link mechanism 8 of the finger mechanism 3, The electric motor 25 (actuator) for operating the 1st joint 13 in the body apparatus frame 24 fixed to the palm part 1, The rotary encoder 26 for detecting the rotary place of this electric motor 25 or the active position of the 1st joint 13 and the reduction gear 27 constituted by the planetary gear mechanism etc. are carried. As shown in drawing 6, the driving shaft 25a of the electric motor 25, It is connected to the axis of rotation 26a of the rotary encoder 26, and the input shaft 27a of the reduction gear 27 via the endless ** belt 28, Rotation of the driving shaft 25a of the electric motor 25 is transmitted to the axis of rotation 26a of the rotary encoder 26, and the input shaft 27a of the reduction gear 27 via the endless ** belt 28.

[0042]The rotation output part 27b which slows down and outputs the rotation which the reduction gear 27 constitutes the 1st joint 13, and is given to the input shaft 27a, That is, it has the rotation output part 27b which rotates with revolving speed later than the input shaft 27a around the axial center (this is the shaft center 13x of the 1st joint 13) of the input shaft 27a. This rotation output part 27b serves as a component of the 2nd link mechanism 9, and the bond part 31 for fixing with the screw 30 and combining the body apparatus frame 29 of the 2nd link mechanism 9, as shown in drawing 7 is formed in one. This body apparatus frame 29 unites with the rotation output part 27b of the reduction gear 27 by combining the body apparatus frame 29 of the 2nd link mechanism 9 with this bond part 31. Thereby, this 2nd link mechanism 9 rotates to the circumference of the axial center of the input shaft 27a of the reduction gear 27 which is the shaft center 13x of the 1st joint 13, when operating the electric motor 25 of the 1st link mechanism 8 (rocking).

[0043]If it is in the 2nd link mechanism 9 by which the body apparatus frame 29 is combined as mentioned above with the bond part 31 of the rotation output part 27b, In the body apparatus frame 29, like the 1st link mechanism 8, the electric motor 32 (actuator), The rotary encoder 33 and the reduction gear 34 are carried, and the driving shaft 32a of the electric motor 32 is connected to the axis of rotation 33a of the rotary encoder 33, and the input shaft 34a of the reduction gear 34 via the endless ** belt 35. In this case, the electric motor 32, the rotary encoder 33, and the reduction gear 34 are in the state which combined the body apparatus

frame 26 with said bond part 37 by the side of the 1st link mechanism 8, and they are arranged so that the shaft center 13x of said 1st joint 13 and those axial centers may cross at right angles.

[0044]The reduction gear 34 of this 2nd link mechanism 9 constitutes said 2nd joint 14, and has the rotation output part 34b which slows down and outputs the rotation given to that input shaft 34a like the reduction gear 27 of the 1st link mechanism 8 as a component of the 3rd link mechanism 10. This rotation output part 34b is formed in the circumference of the axial center of the input shaft 34a of the reduction gear 34 as the shaft center 14x of the 2nd joint 14 pivotable with revolving speed later than this input shaft 34a, The bond part 37 which is fixed to this rotation output part 34b with the screw which does not illustrate the body apparatus frame 36 of the 3rd link mechanism 10, and is combined with it is formed in one. By combining the body apparatus frame 36 of the 3rd link mechanism 10 with this bond part 37, this 3rd link mechanism 10, When operating the electric motor 32 of the 2nd link mechanism 9, it rotates at the rotation output part 34b and one to the circumference of the axial center of the input shaft 34a of the reduction gear 34 which is the shaft center 14x of the 2nd joint 14 (rocking).

[0045]If it is in the 3rd link mechanism 10 by which the body apparatus frame 36 is combined as mentioned above with the bond part 37 of the rotation output part 34b, In the body apparatus frame 36, like the 1st link mechanism 8, the electric motor 38 (actuator), The rotary encoder 39 and the reduction gear 40 are carried, and the driving shaft 38a of the electric motor 38 is connected to the axis of rotation 39a of the rotary encoder 39, and the input shaft 40a of the reduction gear 40 via the endless ** belt 41. In this case, the electric motor 38, the rotary encoder 39, and the reduction gear 40 are in the state which combined the body apparatus frame 36 with said bond part 37 by the side of the 2nd link mechanism 9, and they are arranged so that those axial centers may become parallel to the shaft center 14x of said 2nd joint 14.

[0046]The reduction gear 40 of this 3rd link mechanism 10 constitutes said 3rd joint 15, and has the rotation output part 40b which slows down and outputs the rotation given to that input shaft 40a like the reduction gear 27 of the 1st link mechanism 8 as a component of the 4th link mechanism 11. This rotation output part 40b is formed in the circumference of the axial center of the input shaft 40a of the reduction gear 40 as the shaft center 15x of the 3rd joint 15 pivotable with revolving speed later than this input shaft 40a, and the body part 11a of the 4th link mechanism 11 formed in this rotation output part 40b tabular is formed in one. Thereby, the 4th link mechanism 11 rotates at the rotation output part 40b and one to the circumference of the axial center of the input shaft 40a of the reduction gear 40 which is the shaft center 15x of the 3rd joint 15, when operating the electric motor 38 of the 3rd link mechanism 10 (rocking).

[0047]The connecting part 42 with the 5th link mechanism 12 is formed in the tip part (the rotation output part 40b and the end of an opposite hand) of the body part 11a of the 4th link mechanism 11. This connecting part 42 serves as a component of the 4th joint 16, and the pin hole 43 parallel to the shaft center 15x of the 3rd joint 15 is drilled.

[0048]As shown in drawing 7, the above-mentioned connecting part 42 is inserted in the cut slot 45 formed in the end by the side of the 4th link mechanism 11 of the body apparatus frame 44 of the 5th link mechanism 12, and it is arranged so that the pin hole 46 drilled by the body apparatus frame 44 towards crossing this cut slot 45 and the pin hole 43 of the connecting part 42 may become the same mind. And by inserting the pin 47 in the pin hole 46 of the body apparatus frame 44, and the pin hole 43 of the connecting part 42, the connecting part 42 is connected with the body apparatus frame 44 of the 5th link mechanism 12, and that connecting place comprises this state as the 4th joint 16. That is, the 5th link mechanism 12 is made pivotable at the circumference of the axial center of the pin 47 as the shaft center 16x of the 4th joint 16.

[0049]In this case, in this embodiment, further, as shown in drawing 8, the body apparatus frame 44 of the 5th link mechanism 12 is not only connected with the connecting part 42 of the 4th link mechanism 11 as mentioned above, but is connected with the body apparatus frame 36 of the 3rd link mechanism 10 via the arm piece 48

[0050]The above-mentioned arm piece 48 from the part of rear end part slippage of the lateral portion of the body apparatus frame 44 of the 5th link mechanism 12, With the posture which was missing from the part of tip part slippage of the lateral portion of the body apparatus frame 36 of the 3rd link mechanism 10, and inclined to the longitudinal direction of the finger mechanism 3, have extended and the both ends, It is supported pivotally by the body apparatus frame 44 of the 5th link mechanism 12, and the body apparatus frame 36 of the 3rd link mechanism 10 pivotable via the pivots 49 and 50, respectively.
[0051]By having such an arm piece 48, by the operation of the electric motor 38 of the 3rd link mechanism 10. As the 4th link mechanism 11 shows drawing 8 with an imaginary line, when it rotates to the intrados part side of the finger mechanism 3 (rocking), it rotates around the pin 47 to the 4th link mechanism 11 (rocking), and the 5th link mechanism 12 is bigger angle of rotation than the 4th link mechanism 11, and is rocked to the 3rd link mechanism 10. That is, if the finger mechanism 3 is crooked in the intrados part side in the part of the 3rd joint 15, it is interlocked with and the finger mechanism 3 is crooked in the intrados part side in the part of the 4th joint 16. Therefore, in this embodiment, while the electric motor 38 of the 3rd link mechanism 10 is an actuator which operates the 3rd joint 15, it is also an actuator which operates the 4th joint 16.
[0052]The structure of the finger mechanism 3 explained above is completely the same also about the finger mechanisms 4 and 5. Although a detailed graphic display is omitted, about the finger mechanism 2, the structure of the portion applied to the 3rd joint 23 from the 1st link mechanism 17 is the same as the structure of the portion applied to the 3rd joint 15 from the 1st link mechanism 8 of the above-mentioned finger mechanisms 3-5. Namely, the structure of the 1st link mechanism 17 of the finger mechanism 2, the 2nd link mechanism 18, the 3rd link mechanism 19, the 1st joint 21, the 2nd joint 22, and the 3rd joint 23, It is the same as that of the structure of the 1st link mechanism 8 of the finger mechanisms 3-5, the 2nd link mechanism 9, the 3rd link mechanism 10, the 1st joint 13, the 2nd joint 14, and the 3rd joint 15 respectively.
[0053]And if it is in the finger mechanism 2, only the structure of the 4th link mechanism 20 by the side of a tip is different from the structure of the portion by the side of a tip rather than the 3rd joint 15 of the finger mechanisms 3-5 from the 3rd joint 23. In this case, the 4th link mechanism 20 of the finger mechanism 2 has structure which fixes the 4th link mechanism 11 and the 5th link mechanism 12 in these finger mechanisms 3-5 in one with a screw etc., and was combined, without providing said arm piece 48 like the finger mechanisms 3-5.
[0054]In the hyperdactyly hand equipment of this embodiment explained above, the following operation effects are done so by the above structures.
[0055]For example, from the state (state which extended the hand) which lengthened each finger mechanisms 2-5, the 2nd link mechanism 18 of the finger mechanism 2 is rotated around the shaft center 21x of the 1st joint 21, Turn this 2nd link mechanism 18 in the shaft center 13x and the direction of the 1st joint 13 of the finger mechanism 4, and. The 2nd link mechanism 9 of the finger mechanism 4 is rotated around the shaft center 13x of the 1st joint 13, The case where turned this 2nd link mechanism 9 in the 1st joint 21 and the direction of the finger mechanism 2, and rotated the 3rd link mechanism 10 of the finger mechanism 4 around the shaft center 14x of the 2nd joint 14, and it turns in the shaft center 13x and the direction of the 1st joint 13 of this finger mechanism 4 further is assumed.
[0056]At this time, the shaft center 21x of the 1st joint 21 of the finger mechanism 2, Since the shaft center 13x and abbreviated right angle of the 1st joint 13 of the finger mechanism 4 are crossed, As shown in drawing 9 (a) and (b), rather than the 1st joint 21 of the finger mechanism 2 The portion (portion applied to the 4th link mechanism 20 from the 2nd link mechanism 18) by the side of a tip, Rather than the 2nd joint 14 of the finger mechanism 4, as the portion (portion applied to the 5th link mechanism 12 from the 3rd link mechanism 10) by the side of a tip consists on the same flat surface, those intrados parts meet. Here, drawing 9 (a) is the top view which looked at the hyperdactyly hand equipment which operated the finger mechanisms 2 and

4 as mentioned above from the hand flat surface 6a side in the shaft center 13 x direction of the 1st joint 13 of the finger mechanism 4, and drawing 9 (b) is a perspective view of the hyperdactyly hand equipment in the above-mentioned operating state.

[0057]Thus, since the finger mechanisms 2 and 4 can be made to meet, it is possible to grasp certainly the object which is not illustrated among those finger mechanisms 2 and 4. Although the finger mechanism 4 is made to rotate at this time so that the surroundings of the shaft center 13x of that 1st joint 13 may be approached toward the finger mechanism 5, interference with the finger mechanism 4 is easily avoidable by rotating the finger mechanism 5 around the shaft center 13x of that 1st joint 13.

[0058]Rotate the finger mechanism 5 in the direction which deserts the finger mechanism 4 a little at the circumference of the shaft center 13x of the 1st joint 13 from the state shown in drawing 9, for example, and. The finger mechanism 3 is rotated in the direction made to approach the finger mechanism 4 at the circumference of the shaft center 13x of the 1st joint 13, Bend in the direction in which each the 2nd - 4th joint 14-16 of the finger mechanisms 3-5 are operated, and the tip part of those finger mechanisms 3-5 faces to the finger mechanism 2, and. The 2nd and 3rd joints 22 and 23 of the finger mechanism 2 are operated, and the case where the tip part of this finger mechanism 2 bends in the direction which faces to the finger mechanism 4 is assumed. Thus, the state where the finger mechanisms 2-5 were operated is in the state shown in said drawing 1 - drawing 3.

[0059]Since it inclines mutually at this time as each 1st joint 13 of the finger mechanisms 3-5 showed said drawing 4, the tip part of those finger mechanisms 3-5 approaches mutually, as it will concentrate on a part mutually soon (refer to drawing 1). For this reason, it becomes possible to grasp easily the object which is not illustrated between the finger mechanisms 3-5 and the finger mechanism 2.

[0060]The 1st link mechanism 8 fixed to each palm part 1 of the finger mechanisms 3-5 in this embodiment, Since it has extended radiately toward the tip side of the finger mechanisms 3-5 as shown in said drawing 3, each of those finger mechanisms 3-5, The portion (portion applied to the 5th link mechanism 12 from the 2nd link mechanism 9) by the side of a tip can rotate rather than the 1st joint 13 in a comparatively wide angle range at the circumference of the shaft center 13x of the 1st joint 13 on both sides of the center line C3 of the 1st link mechanism 8, C4, and C5. For this reason, for example, the finger mechanisms 2-5 can be operated in the state where it is shown in drawing 10 (a) and (b).

[0061]Drawing 10 (a) and (b) operates the 1st joint 13 of the finger mechanism 3, and makes the direction which deserts the finger mechanism 4 rotate this finger mechanism 3 from the state shown, for example in drawing 1 - drawing 3, and. By operating the 1st joint 13 of the finger mechanism 5, and making the direction which deserts the finger mechanism 4 rotate this finger mechanism 5, Those finger mechanisms 3 and 5 are the figures showing the state where it was made to meet in the cross direction of the palm part 1, and drawing 10 (a) is the top view which looked at the hyperdactyly hand equipment of this operating state from the hand flat-surface 6a side of the palm part 1 in the shaft center 13 x direction of the 1st joint 13 of the finger mechanism 4. Drawing 10 (b) is a perspective view of the hyperdactyly hand equipment of the above-mentioned operating state.

[0062]Thus, since it aims to differ from this grip direction and an object can be grasped among the finger mechanisms 3 and 5, grasping the object which is not illustrated between the finger mechanism 2 and the finger mechanism 4 when operating the finger mechanisms 2-5, it becomes possible to ensure grasping of this object.

[0063]Since the finger mechanisms 3-5 are the same structures, the hyperdactyly hand equipment of this embodiment can perform diversion between them. For this reason, the inventory management of those finger mechanisms 3-5 in the production plant and workplace of hyperdactyly hand equipment becomes easy, and when either of the finger mechanisms 3-5 breaks down, that exchange treatment can be performed easily.

[0064]Although the embodiment described above explained hyperdactyly hand equipment

provided with the four finger mechanisms 2–5, the number of a finger mechanism is not limited to this and may be provided with the five same finger mechanisms as people's hand, for example.

[0065]Although the structure of a tip part shall differ the finger mechanism 2 equivalent to the thumb from the finger mechanisms 3–5 in said embodiment, it may be a thing of the same structure as the finger mechanisms 3–5.

[0066]Although said embodiment showed what possesses the actuator (electric motor) for operating expansion and contraction of each finger mechanisms 2–5, etc. in each finger mechanisms 2–5, it may be made to form this actuator in the arm object etc. which connect the **** part of hyperdactyly hand equipment, and this. In this case, what is necessary is just made to perform transfer of the power from an actuator to each finger mechanisms 2–5 via the means of transmitting power which comprises a wire, a belt pulley, reduction gears, etc.

[Translation done.]

(19)日本国特許庁（ＪＰ）　(12) 公開特許公報（Ａ）　(11)特許出願公開番号
特開2001－347482
（P2001－347482A）
(43)公開日　平成13年12月18日(2001.12.18)

(51)Int.Cl.⁷	識別記号	ＦＩ	ﾃｰﾏｺｰﾄﾞ(参考)
Ｂ２５Ｊ　15/08		Ｂ２５Ｊ　15/08	Ｊ　３Ｃ００７

審査請求　未請求　請求項の数９　ＯＬ　（全 11 頁）

(21)出願番号　特願2001－52732(P2001－52732)
(22)出願日　平成13年２月27日(2001.2.27)
(31)優先権主張番号　特願2000－102019(P2000－102019)
(32)優先日　平成12年４月４日(2000.4.4)
(33)優先権主張国　日本（ＪＰ）

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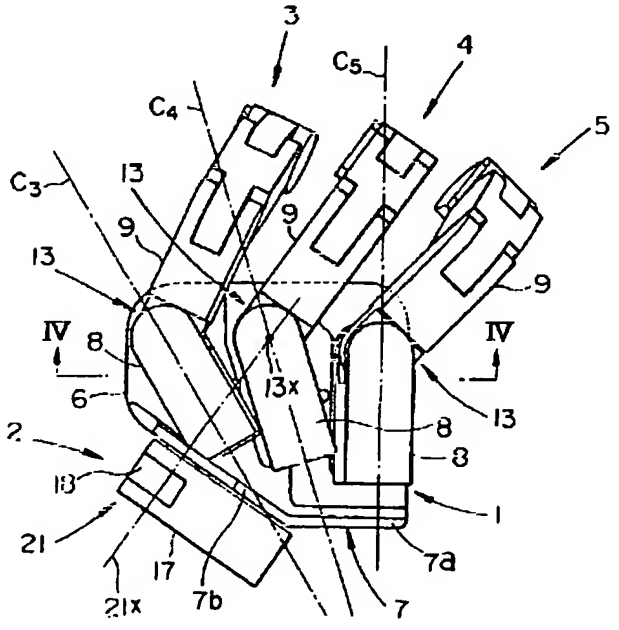
Ｆターム(参考)　3C007 DS01 ES08 ET02 EU08 EU18 EW03 HS27

(54)【発明の名称】　多指ハンド装置

(57)【要約】
【課題】多指ハンド装置による物体の把持動作を容易に効率よく行うことを可能とする多指ハンド装置を提供する。
【解決手段】指機構２～５を有する多指ハンド装置の親指に相当する指機構２の最も手掌部１側の関節２１の回転軸心２１ｘは、指機構４の最も手掌部１側の関節１３の回転軸心１３ｘとほぼ直角に交わる。指機構３～５のそれぞれの最も手掌部１側の関節１３の回転軸心１３ｘは、互いに若干傾斜して手掌部１の手掌本体板６と略直交する方向に延在する。また、指機構３～５のそれぞれの最も手掌部１側リンク機構８は、その中心線Ｃ３，Ｃ４，Ｃ５を互いに傾斜させて手掌部１に固定されている。

FIG. 3



【特許請求の範囲】
【請求項１】手掌部から延設された複数の指機構を備え、各指機構が、前記手掌部側から複数の関節を介して順次連接された複数のリンク機構を具備する多指ハンド装置において、
前記複数の指機構のうちの親指に相当する指機構の最も手掌部側の関節の回転軸心と、該親指に相当する指機構以外の他の指機構のうちの少なくとも一つの指機構の最も手掌部側の関節の回転軸心とが交わるように当該両指機構の最も手掌部側の関節が配置されていることを特徴とする多指ハンド装置。
【請求項２】前記親指に相当する指機構以外の他の全ての指機構のそれぞれの最も手掌部側の関節である第１関節は、その回転軸心を前記手掌部の手平面に略直交する方向に向けて該手掌部の略幅方向に並列して設けられており、
当該他の全ての指機構のそれぞれの前記第１関節に連結して最も手掌部側に位置するリンク機構は、そのそれぞれの幅方向の中心線が相互に傾斜して各指機構の先端側に向かって放射状に広がるように前記手掌部に固定されていることを特徴とする請求項１記載の多指ハンド装置。
【請求項３】前記複数の指機構のうちの親指に相当する指機構以外の他の全ての指機構のそれぞれの最も手掌部側の関節は、該手掌部の略幅方向に並列して設けられると共に、その回転軸心が前記手掌部の手平面に略直交する方向で相互に傾斜し該手掌部の甲側に向かって放射状に広がるように設けられていることを特徴とする請求項１記載の多指ハンド装置。
【請求項４】前記複数の指機構のうちの親指に相当する指機構以外の他の全ての指機構のそれぞれの前記第１関節は、その回転軸心が前記手掌部の手平面に略直交する方向で相互に傾斜し該手掌部の甲側に向かって放射状に広がるように設けられていることを特徴とする請求項２記載の多指ハンド装置。
【請求項５】手掌部から延設された複数の指機構を備え、各指機構が、前記手掌部側から複数の関節を介して順次連接された複数のリンク機構を具備する多指ハンド装置において、
前記複数の指機構のうちの親指に相当する指機構以外の他の全ての指機構のそれぞれの最も手掌部側の関節である第１関節は、その回転軸心を前記手掌部の手平面に略直交する方向に向けて該手掌部の略幅方向に並列して設けられており、
当該他の全ての指機構のそれぞれの前記第１関節に連結して最も手掌部側に位置するリンク機構は、そのそれぞれの幅方向の中心線が相互に傾斜して各指機構の先端側に向かって放射状に広がるように前記手掌部に固定されていることを特徴とする多指ハンド装置。
【請求項６】前記複数の指機構のうちの親指に相当する指機構以外の他の全ての指機構のそれぞれの前記第１関節は、その回転軸心が前記手掌部の手平面に略直交する方向で相互に傾斜し該手掌部の甲側に向かって放射状に広がるように設けられていることを特徴とする請求項５記載の多指ハンド装置。
【請求項７】手掌部から延設された複数の指機構を備え、各指機構が、前記手掌部側から複数の関節を介して順次連接された複数のリンク機構を具備する多指ハンド装置において、
前記複数の指機構のうちの親指に相当する指機構以外の他の全ての指機構のそれぞれの最も手掌部側の関節は、該手掌部の略幅方向に並列して設けられると共に、その回転軸心が前記手掌部の手平面に略直交する方向で相互に傾斜し該手掌部の甲側に向かって放射状に広がるように設けられていることを特徴とする多指ハンド装置。
【請求項８】前記複数の指機構のうち、親指に相当する指機構以外の他の指機構は、その少なくとも二つの指機構が互いに同一構造に構成されていることを特徴とする請求項１～７のいずれか１項に記載の多指ハンド装置。
【請求項９】前記各指機構の各関節の回転駆動を行わしめるアクチュエータを各指機構に具備したことを特徴とする請求項１～８のいずれか１項に記載の多指ハンド装置。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、複数の指機構を有する多指ハンド装置に関する。
【０００２】
【従来の技術】人の手と同様の構造を有する多指ハンド装置は、手掌部から複数の指機構が延設され、その各指機構は、複数の関節を介して複数のリンク機構を順次連接して構成されている。そして、各関節を作動させる（例えば各関節の屈曲動作を行わせる）アクチュエータが、各リンク機構等に設けられている（例えば特開平８－１２６９８４号公報等を参照）。
【０００３】しかしながら、従来の多指ハンド装置は、その各指機構の関節の動作方向や配置構成が、必ずしも多指ハンド装置による種々様々の物体の把持動作を適正に行い得るものとなっているとは言えず、これを改善することが望まれていた。
【０００４】
【発明が解決しようとする課題】本発明はかかる背景に鑑みてなされたものであり、多指ハンド装置による物体の把持動作を容易に効率よく行うことを可能とする多指ハンド装置を提供することを目的とする。
【０００５】
【課題を解決するための手段】本発明の多指ハンド装置は、手掌部から延設された複数の指機構を備え、各指機構が、前記手掌部側から複数の関節を介して順次連接された複数のリンク機構を具備する多指ハンド装置に関す

るものであり、その基本的態様として、第１～第３の態様を有する。

【０００６】この第１の態様では、前記複数の指機構のうちの親指に相当する指機構（以下、ここでは親指機構という）の最も手掌部側の関節（以下、ここでは第１関節という）の回転軸心と、該親指に相当する指機構以外の他の指機構のうちの少なくとも一つの指機構（以下、ここでは特定指機構という）の最も手掌部側の関節の回転軸心とが交わるように（好ましくはほぼ直角に交わるように）当該両指機構の最も手掌部側の関節が配置されている。

【０００７】この構成によれば、前記親指機構の第１関節と前記特定指機構の第１関節との両者又は一方の回転動作を行うことによって、親指機構の第１関節よりも先端側の部分と、特定指機構の第１関節よりも先端側の部分とを同一の平面上で対面させることが可能となる。従って、これらの親指機構と特定指機構との間での物体の把持を容易に行うことができる。

【０００８】尚、本発明の第１の態様では、前記親指機構及び特定指機構のそれぞれの第１関節以外の他の関節は、例えばそれぞれ多軸の自由度を有する構成であってもよいが、特に１軸の自由度を有するものである場合（一つの回転軸心回りの回転動作が可能である場合）には、その回転軸心は、前記第１関節の回転軸心と直交するものであることが好適である。

【０００９】また、本発明の第２の態様では、前記複数の指機構のうちの親指に相当する指機構（親指機構）以外の他の全ての指機構のそれぞれの最も手掌部側の関節である第１関節は、その回転軸心を前記手掌部の手平面に略直交する方向に向けて該手掌部の略幅方向に並列して設けられており、当該他の全ての指機構のそれぞれの前記第１関節に連結して最も手掌部側に位置するリンク機構（以下、ここでは第１リンク機構という）は、そのそれぞれの幅方向の中心線が相互に傾斜して各指機構の先端側に向かって放射状に広がるように前記手掌部に固定されている。

【００１０】この第２の態様によれば、親指機構以外の他の全ての指機構、すなわち、前記手掌部の略幅方向に並列している指機構は、そのそれぞれの前記第１関節の回転軸が手掌部の手平面に略直交する方向に向けられているため、それらの指機構の第１関節よりも先端側の部分は、該第１関節の箇所において、手掌部の手平面に略沿った回転動作を行うことが可能である。そして、このとき、親指機構以外の指機構の第１リンク機構は、そのそれぞれの幅方向の中心線が相互に傾斜して各指機構の先端側に向かって放射状に広がるように前記手掌部に固定されているため、各指機構を、隣合う指機構との干渉を避けつつ広い回転範囲にわたって、第１関節の回転軸心の回りに回転させることが可能となる。つまり親指機構以外の各指機構と、隣合う指機構とを必要以上にそれぞれの第１関節の回転軸心回りに回転させることなく、比較的広い範囲にわたって第１関節の回転軸心回りに回転させることが可能となる。この結果、指機構は、種々様々の物体の把持に適した姿勢を容易に採ることが可能となる。

【００１１】尚、本発明の第２の態様において、親指機構以外の各指機構の第１関節以外の各関節は、特に１軸の自由度を有するものである場合には、その回転軸心が、第１関節の回転軸心と直交するものであることが好適である。また、親指機構については、その各関節が、１軸の自由度を有するものである場合には、最も手掌部側の第１関節の回転軸心が他の指機構の第１関節の回転軸心と略直交し、さらに、該親指機構の他の各関節の回転軸心は、該親指機構の第１関節の回転軸心と直交するものであることが好ましい。

【００１２】また、本発明の第３の態様では、前記複数の指機構のうちの親指に相当する指機構（親指機構）以外の他の全ての指機構のそれぞれの最も手掌部側の関節（第１関節）は、該手掌部の略幅方向に並列して設けられると共に、その回転軸心が前記手掌部の手平面に略直交する方向で相互に傾斜し該手掌部の甲側に向かって放射状に広がるように設けられている。

【００１３】かかる本発明の第３の態様によれば、親指機構以外の他の指機構の最も手掌部側の第１関節の回転軸心が手掌部の手平面に略直交する方向で相互に傾斜し該手掌部の甲側に向かって放射状に広がるように設けられているので、それらの各指機構の第１関節よりも先端側の関節を作動させて、該第１関節よりも先端側の部分を手平面側に折り曲げるようにしたとき、それらの指機構の先端部が近傍箇所に集中しやすくなる。このため、それらの指機構を用いた物体の把持が容易になる。

【００１４】尚、本発明の第３の態様においては、第２の態様と同様、親指機構以外の各指機構の第１関節以外の各関節は、特に１軸の自由度を有するものである場合には、その回転軸心が、第１関節の回転軸心と直交するものであることが好適である。また、親指機構については、その各関節が、１軸の自由度を有するものである場合には、最も手掌部側の第１関節の回転軸心が他の指機構の第１関節の回転軸心と略直交し、さらに、該親指機構の他の各関節の回転軸心は、該親指機構の第１関節の回転軸心と直交するものであることが好ましい。

【００１５】以上説明した本発明の第１～第３の態様は、複合的に採用してもよいことはもちろんである。この場合、本発明の第１の態様に、さらに第２の態様を採用する場合には、前記親指に相当する指機構（親指機構）以外の他の全ての指機構のそれぞれの最も手掌部側の関節である第１関節は、その回転軸心を前記手掌部の手平面に略直交する方向に向けて該手掌部の略幅方向に並列して設けられ、当該他の全ての指機構のそれぞれの前記第１関節に連結して最も手掌部側に位置するリンク

機構は、そのそれぞれの幅方向の中心線が相互に傾斜して各指機構の先端側に向かって放射状に広がるように前記手掌部に固定される。

【００１６】さらに、本発明の第１の態様に、第３の態様を採用する場合には、前記複数の指機構のうちの親指に相当する指機構（親指機構）以外の他の全ての指機構のそれぞれの最も手首部側の関節（第１関節）は、該手首部の略幅方向に並列して設けられると共に、その回転軸心が前記手掌部の手平面に略直交する方向で相互に傾斜し該手掌部の甲側に向かって放射状に広がるように設けられる。

【００１７】また、本発明の第２の態様に、第３の態様を採用する場合には、前記複数の指機構のうちの親指に相当する指機構（親指機構）以外の他の全ての指機構のそれぞれの前記第１関節は、その回転軸心が前記手掌部の手平面に略直交する方向で相互に傾斜し該手掌部の甲側に向かって放射状に広がるように設けられる。

【００１８】以上説明した本発明では、第１～第３のいずれの態様においても、前記複数の指機構のうち、親指に相当する指機構（親指機構）以外の他の指機構は、その少なくとも二つの指機構が互いに同一構造に構成されていることが好ましい。

【００１９】これによれば、同一構造の指機構同士は、相互に転用することができる。このため、それらの指機構の在庫管理が容易になると共に、それらの指機構の一つが故障した場合における該指機構の交換処置に容易に対応することができる。

【００２０】また、本発明では、第１～第３のいずれの態様においても、各指機構の各関節の回転動作を行わしめるアクチュエータを例えば各指機構に具備する。この場合特に、前記のように少なくとも二つの指機構が互いに同一構造に構成されているときには、各指機構の各関節の回転動作を行わしめるアクチュエータを各指機構に具備することにより、同一構造の指機構同士は該アクチュエータを含めて相互に転用することができる。

【００２１】尚、本発明における各指機構の関節の駆動機構については、例えば、各指機構の最も先端側のリンク機構以外の各リンク機構に、これと隣合うリンク機構との間の関節を駆動するための電動モータ等の回転駆動手段と、この回転駆動手段の回転駆動力を該関節に伝達する回転伝達手段（減速装置等を含む）とを搭載した構成とすることが好ましい。

【００２２】

【発明の実施の形態】本発明の一実施形態を図１～図１０を参照して説明する。

【００２３】図１及び図２は本実施形態の多指ハンド装置の基本構造を示す斜視図であり、図１は多指ハンド装置の手平面を上側にして示した斜視図、図２は多指ハンド装置の手甲側を上側にして示した斜視図である。尚、図１及び図２では、説明の便宜上、多指ハンド装置の各指機構２～５は、その要部構成のみを簡略化して記載し、アクチュエータ等の構成要素を省略している。

【００２４】図１及び図２に示すように、本実施形態の多指ハンド装置は、手掌部１と、この手掌部１から延設された複数の指機構２～５とを具備している。指機構２～５は、本実施形態では４本であり、このうち、指機構２は人の手の親指に相当するものである。

【００２５】手掌部１は、板状部材により形成されたものであり、表面が手平面６ａ（図１参照）となる手掌本体板６と、この手掌本体板６の後端部から該手掌本体板６と略直交する姿勢で手甲側（手掌本体板６の裏面側）に起立された起立板７とから構成されている。手掌本体板６の裏面（手甲側の面）は、指機構２～５のうちの指機構３～５が取付けられる面部である（図２参照）。

【００２６】起立板７は、手掌部１の略幅方向に延在する第１部分起立板７ａと、この第１部分起立板７ａの一端側で該第１部分起立板７ａに対して傾斜して延在する第２部分起立板７ｂとから成る。第１部分起立板７ａは、図示しないロボットのアーム（腕体）に取付けられる部分、第２部分起立板７ｂは、指機構２が取付けられる部分である。

【００２７】指機構２～５のうち、指機構３～５は、いずれも同一構造であり、それぞれ、第１～第５の５個のリンク機構８～１２を手掌部１側から順に第１～第４の４個の関節１３～１６を介して連接した構造となっている。尚、指機構３～５は、上記のようにいずれも同一構造であることから、図１及び図２では、便宜上、指機構４については、各リンク機構及び各関節の参照符号を省略している。

【００２８】これらの指機構３～５のより詳細な構造は後述するが、それぞれの各関節１３～１６は、いずれも一軸回りの回転運動を可能とする関節である。そして、本実施形態では、最も手掌部１寄りの第１関節１３の回転軸心は、他の三つの第２～第４関節１４～１６の回転軸心（これらは互いに平行である）と直交している。

【００２９】すなわち、例えば指機構５について図１を参照して説明すると、この指機構５の第１関節１３は、図示の回転軸心１３ｘの回りに第２リンク機構９を第１リンク機構８に対して回転可能とし、第２関節１４は、第１関節１３の回転軸心１３ｘと直交する回転軸心１４ｘの回りに第３リンク機構１０を第２リンク機構９に対して回転可能としている。さらに、第３関節１５は、第２関節１４の回転軸心１４ｘと平行な回転軸心１５ｘの回りに第４リンク機構１１を第３リンク機構１０に対して回転可能とし、第４関節１６は、第３関節１５の回転軸心１５ｘと平行な回転軸心１６ｘの回りに第５リンク機構１２を第４リンク機構１１に対して回転可能としている。

【００３０】このような第１～第４関節１３～１６の回転動作は、指機構３，４についても全く同様である。そ

して、本実施形態では、指機構3～5のそれぞれの第1リンク機構8が、第1関節13の回転軸心13xを手掌部1の手掌本体板6と略直交する方向に向けて該手掌本体板6の裏面部に固設され、該手掌本体板6の略幅方向に並列している（図2参照）。

【0031】ここで、手掌本体板6と指機構3～5のそれぞれの第1リンク機構8との取付け構成についてさらに図3及び図4を参照して説明する。図3は、図2のIII矢視図（手掌部1の手甲側から指機構4の第1関節13の回転軸心13x方向で見た平面図）、図4は図3のIV-IV線断面図である。尚、図4では指機構3～5の第1リンク機構8を仮想線で示している。

【0032】本実施形態では、図3に示すように、指機構3～5のそれぞれの第1リンク機構8は、その幅方向の中心線C3，C4，C5が互いに傾斜し、且つ、それらの中心線C3，C4，C5が指機構3～5の先端側に向かって放射状に広がるようにして、手掌本体板6の裏面部に固設されている。このため、指機構3～5をそれぞれ中心線C3，C4，C5の方向に伸ばしたとき、指機構3～5は、手掌部1側から放射状に延在することとなる。

【0033】また、本実施形態では、手掌本体板6は、図4に示すように、幅方向で手平面6a側に若干屈曲するように形成されており、手掌本体板6の裏面部の、指機構3の第1リンク機構8を固着する面部6xと、指機構4の第1リンク機構8を固着する面部6yと、指機構5の第1リンク機構8を固着する面部6zとは、互いに若干傾斜している。このため、これらの面部6x，6y，6zに指機構3～5のそれぞれの第1リンク機構8を固設した状態では、各指機構3～5の最も手掌部1側の関節である第1関節13の回転軸心13xも互いに若干傾斜し、それらの回転軸心13xは、図示のように手甲側に向かって放射状に広がるように延在する。尚、この場合、本実施形態では、指機構4の第1関節13の回転軸心13x（これは図4の鉛直方向に延在する）に対する指機構5の第1関節13の回転軸心13xの傾斜角度θaは、指機構4の第1関節13の回転軸心13xに対する指機構3の第1関節13の回転軸心13xの傾斜角度θb（例えば5度）とほぼ同じかもしくはそれよりも若干大きな角度（例えば5～10度）になっている。

【0034】一方、図1及び図2を参照して、指機構2は、第1～第4の4個のリンク機構17～20を手掌部1側から順に第1～第3の3個の関節21～23を介して連接した構造となっている。

【0035】この指機構2の各関節21～23は、前記指機構3～5の第1～第3関節13～15と同様、いずれも一軸回りの回転運動を可能とする関節であり、最も手掌部1寄りの第1関節21の回転軸心は、他の二つの第2及び第3関節22，23の回転軸心（これらは互いに平行である）と直交している。

【0036】すなわち、図1参照して、指機構2の第1関節21は、図示の回転軸心21xの回りに第2リンク機構18を第1リンク機構17に対して回転可能とし、第2関節22は、第1関節21の回転軸心21xと直交する回転軸心22xの回りに第3リンク機構19を第2リンク機構18に対して回転可能としている。さらに、第3関節23は、第2関節22の回転軸心22xと平行な回転軸心23xの回りに第4リンク機構20を第3リンク機構19に対して回転可能としている。

【0037】そして、本実施形態では、指機構2は、その第1リンク機構17が、第1関節21の回転軸心21xを手掌部1の第2部分起立板7bと直交する方向（手掌本体板6と略平行な方向）に向けて該第2部分起立板7bの外表面部に固設されている。

【0038】この場合、本実施形態では、指機構2は、その第1関節21の回転軸心21xが前記図3に示すように、前述の他の指機構3～5のうちの指機構4の第1関節13の回転軸心13xと略直角に交わるような位置及び姿勢で、第2部分起立板7bに固定されている。

【0039】前記指機構2～5のさらに詳細な構造を図5～図8を参照して説明する。

【0040】図5及び図6は、同一構造である指機構3～5のうちの例えば指機構3を各関節13～16の箇所で分解して示した分解斜視図である。この場合、図5では、指機構3の腹側の側面部、すなわち指機構3の、前記手掌部1の手平面6aと同じ側の側面部であって、図1及び図2ように指機構3を屈曲させた状態で手掌部1の手平面6aに対面する側面部（以下、腹面部という）が図5中の矢印Aの方向（上方向）に向けられている。また、図6では、指機構3の腹面部が同図中の矢印Bの方向（横方向）に向けられている。また、図7は指機構3を伸ばした状態で、その腹面部側から見た平面図、図8は図7のVIII矢視図である。

【0041】図5～図7に示すように、指機構3の第1リンク機構8は、手掌部1に固定される本体機枠24に、第1関節13を動作させるための電動モータ25（アクチュエータ）と、該電動モータ25の回転位置あるいは第1関節13の動作位置を検出するためのロータリエンコーダ26と、遊星歯車機構等により構成された減速装置27とを搭載している。図6に示すように、電動モータ25の駆動軸25aは、無端条ベルト28を介してロータリエンコーダ26の回転軸26a及び減速装置27の入力軸27aに接続され、電動モータ25の駆動軸25aの回転が無端条ベルト28を介してロータリエンコーダ26の回転軸26a及び減速装置27の入力軸27aに伝達されるようになっている。

【0042】減速装置27は、第1関節13を構成するものであり、その入力軸27aに与えられる回転を減速して出力する回転出力部27b、すなわち、入力軸27aよりも遅い回転速度で入力軸27aの軸心（これは第1関節13の回転軸心13xである）の回りに回転する

回転出力部２７ｂを備えている。この回転出力部２７ｂは、第２リンク機構９の構成要素となるもので、第２リンク機構９の本体機枠２９を図７に示すようにネジ３０により固定して結合するための結合部３１が一体に設けられている。該結合部３１に第２リンク機構９の本体機枠２９を結合することにより該本体機枠２９が減速装置２７の回転出力部２７ｂと一体化する。これにより、該第２リンク機構９は、第１リンク機構８の電動モータ２５を作動させたとき、第１関節１３の回転軸心１３ｘである減速装置２７の入力軸２７ａの軸心回りに回転（揺動）する。

【００４３】上記のように回転出力部２７ｂの結合部３１に本体機枠２９が結合される第２リンク機構９にあっては、その本体機枠２９に、第１リンク機構８と同様、電動モータ３２（アクチュエータ）、ロータリエンコーダ３３及び減速装置３４が搭載され、電動モータ３２の駆動軸３２ａが無端条ベルト３５を介してロータリエンコーダ３３の回転軸３３ａ及び減速装置３４の入力軸３４ａに接続されている。この場合、電動モータ３２、ロータリエンコーダ３３及び減速装置３４は、本体機枠２９を第１リンク機構８側の前記結合部３１に結合した状態で、それらの軸心が前記第１関節１３の回転軸心１３ｘと直交するように配置されている。

【００４４】この第２リンク機構９の減速装置３４は、前記第２関節１４を構成するもので、第１リンク機構８の減速装置２７と同様、その入力軸３４ａに与えられる回転を減速して出力する回転出力部３４ｂを第３リンク機構１０の構成要素として有している。該回転出力部３４ｂは、第２関節１４の回転軸心１４ｘとしての減速装置３４の入力軸３４ａの軸心回りに該入力軸３４ａよりも遅い回転速度で回転可能に設けられ、この回転出力部３４ｂに、第３リンク機構１０の本体機枠３６を図示しないネジにより固定して結合する結合部３７が一体に設けられている。該結合部３７に第３リンク機構１０の本体機枠３６を結合することにより、該第３リンク機構１０は、第２リンク機構９の電動モータ３２を作動させたとき、第２関節１４の回転軸心１４ｘである減速装置３４の入力軸３４ａの軸心回りに回転出力部３４ｂと一体に回転（揺動）する。

【００４５】上記のように回転出力部３４ｂの結合部３７に本体機枠３６が結合される第３リンク機構１０にあっては、その本体機枠３６に、第１リンク機構８と同様、電動モータ３８（アクチュエータ）、ロータリエンコーダ３９及び減速装置４０が搭載され、電動モータ３８の駆動軸３８ａが無端条ベルト４１を介してロータリエンコーダ３９の回転軸３９ａ及び減速装置４０の入力軸４０ａに接続されている。この場合、電動モータ３８、ロータリエンコーダ３９及び減速装置４０は、本体機枠３６を第２リンク機構９側の前記結合部３７に結合した状態で、それらの軸心が前記第２関節１４の回転軸心１４ｘと平行になるように配置されている。

【００４６】この第３リンク機構１０の減速装置４０は、前記第３関節１５を構成するもので、第１リンク機構８の減速装置２７と同様、その入力軸４０ａに与えられる回転を減速して出力する回転出力部４０ｂを第４リンク機構１１の構成要素として有している。該回転出力部４０ｂは、第３関節１５の回転軸心１５ｘとしての減速装置４０の入力軸４０ａの軸心回りに該入力軸４０ａよりも遅い回転速度で回転可能に設けられ、この回転出力部４０ｂに、板状に形成された第４リンク機構１１の本体部１１ａが一体に設けられている。これにより、第４リンク機構１１は、第３リンク機構１０の電動モータ３８を作動させたとき、第３関節１５の回転軸心１５ｘである減速装置４０の入力軸４０ａの軸心回りに回転出力部４０ｂと一体に回転（揺動）する。

【００４７】第４リンク機構１１の本体部１１ａの先端部（回転出力部４０ｂと反対側の端部）には、第５リンク機構１２との連結部４２が設けられている。該連結部４２は、第４関節１６の構成要素となるもので、第３関節１５の回転軸心１５ｘと平行なピン穴４３が穿設されている。

【００４８】上記連結部４２は、図７に示すように、第５リンク機構１２の本体機枠４４の第４リンク機構１１側の端部に形成された切込溝４５に挿入され、該切込溝４５を横断する方向で本体機枠４４に穿設されたピン穴４６と連結部４２のピン穴４３とが同心になるように配置される。そして、この状態で、本体機枠４４のピン穴４６及び連結部４２のピン穴４３にピン４７を挿通することにより、連結部４２が第５リンク機構１２の本体機枠４４に連結され、その連結箇所が第４関節１６として構成される。すなわち、第５リンク機構１２は、第４関節１６の回転軸心１６ｘとしてのピン４７の軸心回りに回転可能とされる。

【００４９】この場合、本実施形態では、第５リンク機構１２の本体機枠４４は、上記のように第４リンク機構１１の連結部４２に連結されているだけでなく、さらに、図８に示すようにアーム片４８を介して第３リンク機構１０の本体機枠３６に連結されている。

【００５０】上記アーム片４８は、第５リンク機構１２の本体機枠４４の側面部の後端部寄りの箇所から、第３リンク機構１０の本体機枠３６の側面部の先端部寄りの箇所にかけて指機構３の長手方向に対して傾斜した姿勢で延在しており、その両端部は、それぞれ第５リンク機構１２の本体機枠４４と第３リンク機構１０の本体機枠３６とに支軸４９，５０を介して回転可能に軸支されている。

【００５１】このようなアーム片４８を備えていることにより、第３リンク機構１０の電動モータ３８の作動によって、第４リンク機構１１が図８に仮想線で示すように指機構３の腹面部側に回転（揺動）されたとき、第５

リンク機構12は、第4リンク機構11に対してピン47の回りに回転（揺動）し、第4リンク機構11よりも大きな回転角度で、第3リンク機構10に対して揺動する。つまり、第3関節15の箇所で指機構3がその腹面部側に屈曲すると、それに連動して、第4関節16の箇所で、指機構3がその腹面部側に屈曲する。従って、本実施形態では第3リンク機構10の電動モータ38は、第3関節15を作動させるアクチュエータであると同時に、第4関節16を作動させるアクチュエータでもある。

【0052】以上説明した指機構3の構造は、指機構4，5についても全く同一である。尚、詳細な図示は省略するが、指機構2については、その第1リンク機構17から第3関節23にかけての部分の構造は、前述の指機構3～5の第1リンク機構8から第3関節15にかけての部分の構造と同一である。すなわち、指機構2の第1リンク機構17、第2リンク機構18、第3リンク機構19、第1関節21、第2関節22及び第3関節23の構造は、それぞれ指機構3～5の第1リンク機構8、第2リンク機構9、第3リンク機構10、第1関節13、第2関節14及び第3関節15の構造と同一である。

【0053】そして、指機構2にあっては、第3関節23より先端側の第4リンク機構20の構造のみが、指機構3～5の第3関節15よりも先端側の部分の構造と相違するものとなっている。この場合、指機構2の第4リンク機構20は、指機構3～5のような前記アーム片48を具備せずに、該指機構3～5における第4リンク機構11と第5リンク機構12とをネジ等により一体的に固定して結合したような構造となっている。

【0054】以上説明した本実施形態の多指ハンド装置では、前述のような構造によって、次のような作用効果を奏する。

【0055】例えば各指機構2～5を伸ばした状態（手を広げた状態）から、指機構2の第2リンク機構18を第1関節21の回転軸心21xの回りに回転させて、該第2リンク機構18を指機構4の第1関節13の回転軸心13xと同方向に向けると共に、指機構4の第2リンク機構9を第1関節13の回転軸心13xの回りに回転させて、該第2リンク機構9を指機構2の第1関節21と同方向に向け、さらに、指機構4の第3リンク機構10を第2関節14の回転軸心14xの回りに回転させて該指機構4の第1関節13の回転軸心13xと同方向に向けた場合を想定する。

【0056】このとき、指機構2の第1関節21の回転軸心21xは、指機構4の第1関節13の回転軸心13xと略直角に交わっているため、図9（a），（b）に示すように、指機構2の第1関節21よりも先端側の部分（第2リンク機構18から第4リンク機構20にかけての部分）と、指機構4の第2関節14よりも先端側の部分（第3リンク機構10から第5リンク機構12にかけての部分）とが同一平面上に存するようにして、それらの腹面部が対面する。ここで、図9（a）は、上記のように指機構2，4を作動させた多指ハンド装置を、手平面6a側から、指機構4の第1関節13の回転軸心13x方向で見た平面図であり、図9（b）は、上記の作動状態における多指ハンド装置の斜視図である。

【0057】このように、指機構2，4を対面させることができるため、それらの指機構2，4の間で、図示しない物体を確実に把持することが可能である。また、このとき、指機構4は、その第1関節13の回転軸心13xの回りに、指機構5に向かって接近するように回転させることとなるが、指機構5をその第1関節13の回転軸心13xの回りに回転させることで、指機構4との干渉を容易に回避することができる。

【0058】また、例えば、図9に示した状態から、指機構5をその第1関節13の回転軸心13x回りに指機構4から若干離反する方向に回転させると共に、指機構3をその第1関節13の回転軸心13x回りに指機構4に接近させる方向に回転させ、さらに、指機構3～5のそれぞれの第2～第4関節14～16を作動させてそれらの指機構3～5の先端部が指機構2に向かう方向に折り曲げると共に、指機構2の第2及び第3関節22，23を作動させて該指機構2の先端部が指機構4に向かう方向に折り曲げた場合を想定する。このように指機構2～5を作動させた状態が前記図1～図3に示した状態である。

【0059】このとき、指機構3～5のそれぞれの第1関節13が前記図4に示したように互いに傾斜しているため、それらの指機構3～5の先端部は、互いに近傍箇所に集中するようにして互いに接近する（図1参照）。このため、指機構3～5と指機構2との間で、図示しない物体を容易に把持することが可能となる。

【0060】さらに、本実施形態では、指機構3～5のそれぞれの、手掌部1に固定された第1リンク機構8は、前記図3に示したように指機構3～5の先端側に向かって放射状に延在しているため、それらの各指機構3～5は、その第1関節13よりも先端側の部分（第2リンク機構9から第5リンク機構12にかけての部分）が、第1リンク機構8の中心線C3，C4，C5の両側に、第1関節13の回転軸心13x回りに比較的広い角度範囲で回転することができる。このため、例えば、図10（a），（b）に示すような状態に指機構2～5を作動させることができる。

【0061】図10（a），（b）は、例えば図1～図3に示した状態から、指機構3の第1関節13を作動させて該指機構3を指機構4から離反する向きに回転させると共に、指機構5の第1関節13を作動させて該指機構5を指機構4から離反する向きに回転させることにより、それらの指機構3，5が手掌部1の幅方向で対面す

るようにした状態を示す図であり、図１０（ａ）は、この作動状態の多指ハンド装置を手掌部１の手平面６ａ側から、指機構4の第１関節１３の回転軸心１３ｘ方向で見た平面図である。また、図１０（ｂ）は、上記作動状態の多指ハンド装置の斜視図である。

【００６２】このように指機構２～５を作動させたとき、指機構２と指機構4との間に図示しない物体を把持しつつ、この把持方向とは異なる方向で、指機構３，５の間で物体を把持することができるため、該物体の把持を確実に行うことが可能となる。

【００６３】また、本実施形態の多指ハンド装置は、指機構３～５が同一構造であるため、それらの間での転用ができる。このため、多指ハンド装置の生産工場や作業場におけるそれらの指機構３～５の在庫管理が容易になると共に、指機構３～５のいずれかが故障した場合等にその交換処置を容易に行うことができる。

【００６４】尚、以上説明した実施形態では、４本の指機構２～５を備えた多指ハンド装置を説明したが、指機構の本数はこれに限定されるものではなく、例えば、人の手と同じ５本の指機構を備えるものであってもよい。

【００６５】また、前記実施形態では、親指に相当する指機構２を指機構３～５と、先端部の構造が異なるものとしたが、指機構３～５と同一構造のものであってもよい。

【００６６】また、前記実施形態では、各指機構２～５の屈伸等の動作を行うためのアクチュエータ（電動モータ）を各指機構２～５に具備したものを示したが、該アクチュエータは、多指ハンド装置の手掌部やこれを連結する腕体等に設けるようにしてもよい。この場合、アクチュエータから各指機構２～５への動力の伝達は例えばワイヤやプーリ、減速機等から構成される動力伝達手段を介して行うようにすればよい。

【図面の簡単な説明】

【図１】本発明の一実施形態における多指ハンド装置の斜視図。

【図２】図１の多指ハンド装置を図１とは異なる方向から見た斜視図。

【図３】図２のIII矢視図。

【図４】図３のIV－IV線断面図。

【図５】図１及び図２の多指ハンド装置の指機構の分解斜視図。

【図６】図１及び図２の多指ハンド装置の指機構の分解斜視図。

【図７】図１及び図２の多指ハンド装置の指機構の平面図。

【図８】図７のVIII矢視図。

【図９】図１及び図２の多指ハンド装置の一例の作動状態を示す平面図及び斜視図。

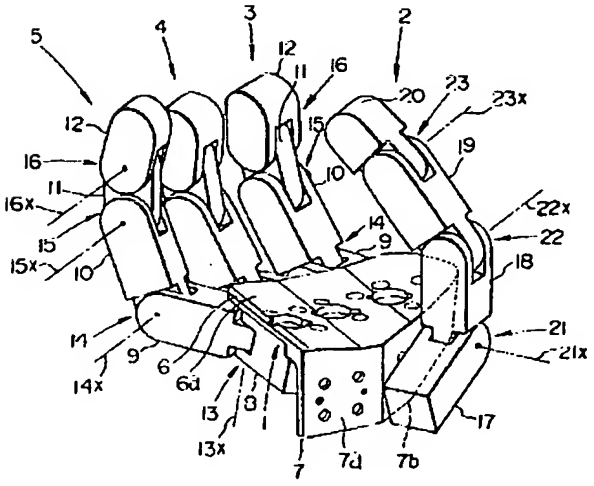
【図１０】図１及び図２の多指ハンド装置の他の例の作動状態を示す平面図及び斜視図。

【符号の説明】

1…手掌部、2～5…指機構、６ａ…手平面、８～１２，１７～２０…リンク機構、１３～１６，２１～２３…関節、２５，３２，３８…電動モータ（アクチュエータ）。

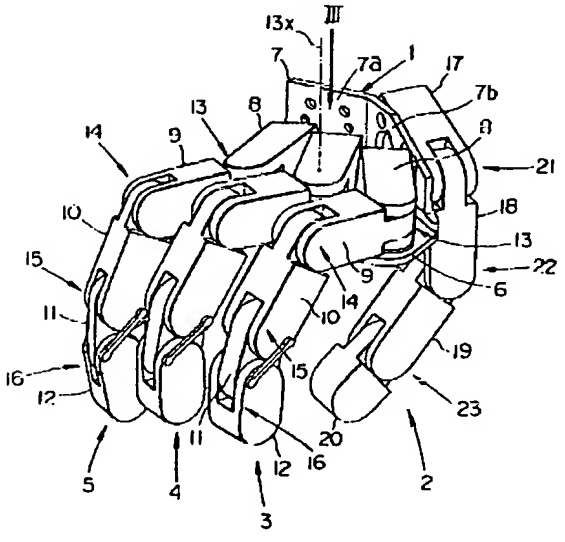
【図1】

FIG. 1



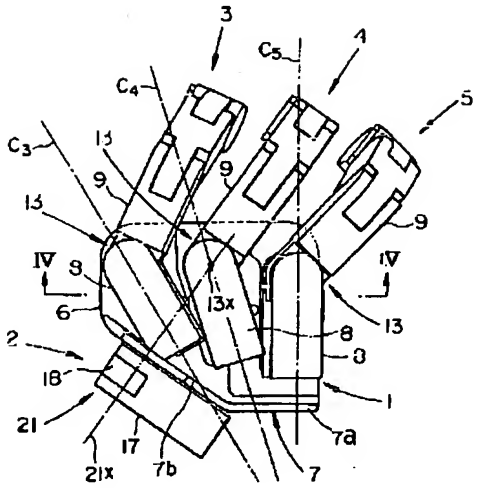
【図2】

FIG. 2



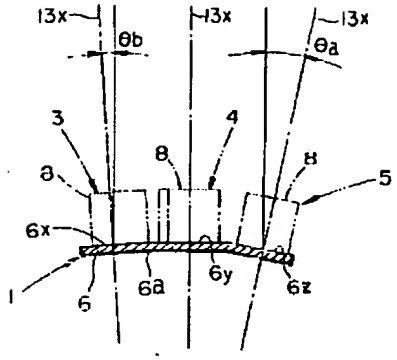
【図3】

FIG. 3



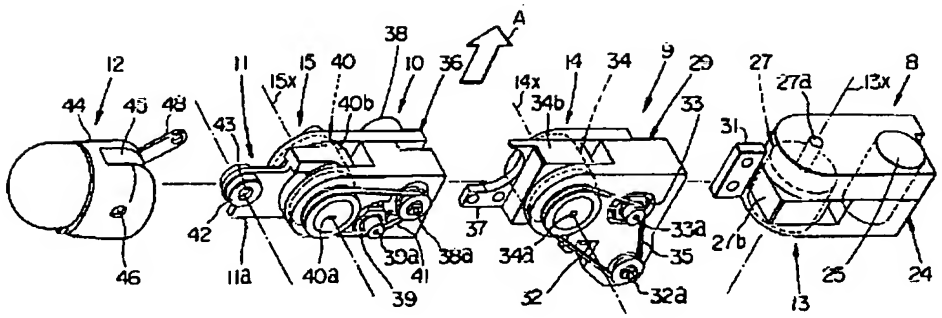
【図4】

FIG. 4



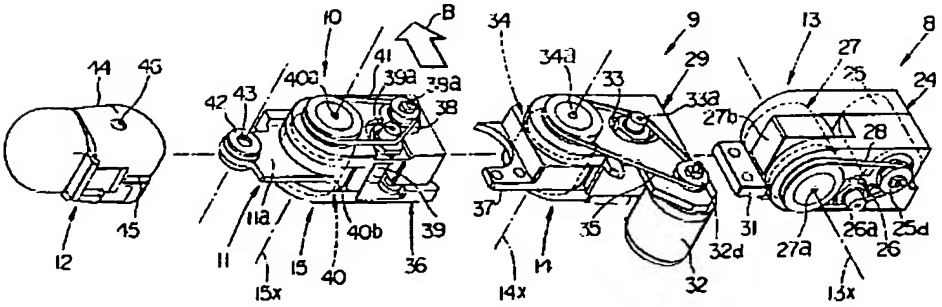
【図5】

FIG. 5



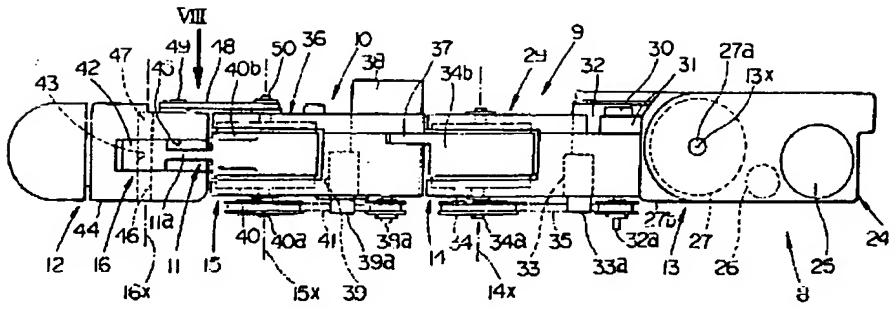
【図6】

FIG. 6



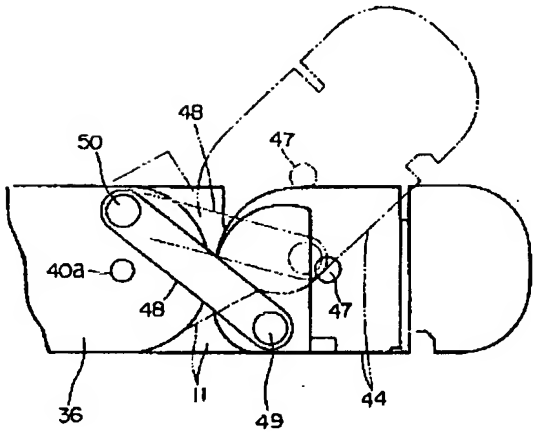
【図7】

FIG. 7



【図8】

FIG. 8



【図9】

FIG. 9(a)

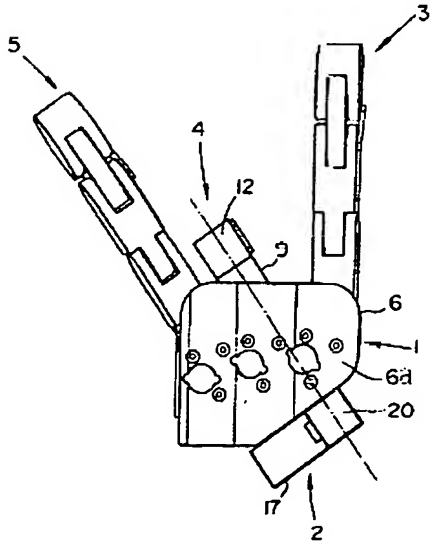
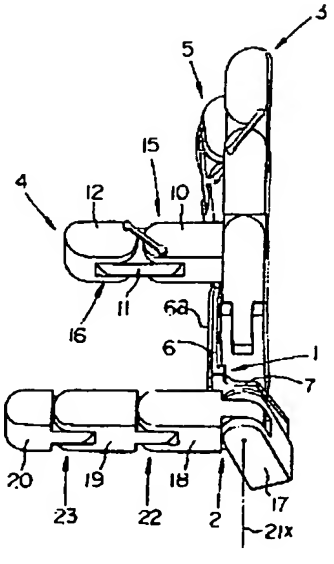


FIG. 9(b)



【図10】

FIG. 10(a)

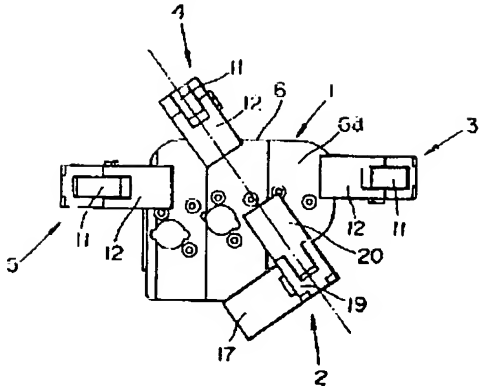


FIG. 10(b)